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## SUGAR-CANE FUNGI AND DISEASES OF PORTO RICO.<sup>1</sup>

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### INTRODUCTION.

#### THE NEED FOR INVESTIGATIONS OF CANE FUNGI.

The sugar cane (*Saccharum officinarum*) as an economic crop has been grown in Porto Rico since at least 1548, when the first mill was erected and during all this period has doubtless suffered from the various common diseases, although no published reports are available until about 1870-80. During this latter period there occurred a most serious epidemic in the western section of the Island, occasioning heavy loss. From that time on, although the epidemic as such passed, there was continued loss through cane diseases, combatted as information given by planters indicates, by change of land and the introduction of new varieties. Following the American occupation, which gave a great impetus to the industry, the greatly increased areas given over to cane have meant increased losses from fungus attacks, more especially where the extra care in cultivation, so necessary when one crop is grown continuously, has not been given.

In some years it has been common to find whole fields ruined by one or another disease; and in certain areas it is impossible to grow more than one or two crops of cane without a period of rest, in contrast to many parts of Cuba and Santo Domingo where an indefinite number of ratoon crops are obtained without replanting.

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<sup>1</sup> This paper was originally prepared by Mr. Johnston previous to his resignation in September, 1914, as pathologist of the Insular Experiment Station and was at that time nearly complete, including drawings and photographs. Circumstances not having permitted of its publication before the present date it has now been completely revised and rewritten to permit of the inclusion of all data obtained in the past three years by the junior author, who has carried on the work since Mr. Johnston's departure as well as having been connected with the project for a year previous to that time as assistant pathologist. A considerable number of additional species, some of them new, have been added, and others originally only provisionally named have been determined and inserted, together with many supplementary notes and observations on the other species. The drawings are the work of the senior author, the photographs were for the most part originally prepared jointly, and the present selections and arrangements have been by the junior author, including some new additions.

Acknowledgment is made for assistance in the matter of determinations to Mrs. F. W. Patterson, U. S. Department of Agriculture; Dr. E. A. Burt, Missouri Botanical Garden; Dr. F. J. Seaver, and Dr. W. A. Merrill, New York Botanical Garden; Prof. C. G. Lloyd; and Dr. W. C. Sturgis. Further acknowledgment is made in connection with the description of each species on which help has been had.

The junior author assumes responsibility for the form in which the paper is here presented as well as for any errors that may occur.

In some cases it is impossible to grow any cane whatever on what appears to be fairly good soil. Furthermore, in many fields of healthy looking cane it is not uncommon to find an enormous number of stalks completely rotted.

In the course of the field work carried on by this department, numerous cases of loss (totalling many acres) from root disease, rind disease and other causes have been investigated. To the losses from the all-sufficient array of common diseases heretofore known, is now added the epidemic in the northwestern quarter of the Island, where the monetary loss has already reached a total of some hundreds of thousands of dollars. It should by no means be considered that diseased cane is more abundant than healthy, but rather that it is often found very abundant over large areas, and far more prevalent than should be the case.

Although sugar cane diseases have been studied for many years, yet even today there is considerable contradiction to be found in the literature on the subject as to the cause of certain diseases and as to their relative importance. This lack of unanimity of opinion is partly due to inaccurate, or to incomplete work on the part of some of the investigators, but is also due in part to the fact that certain fungi causing disease vary in their behavior in different localities, in different countries, and in different varieties of cane.

For these reasons the work of sugar cane pathologists in other countries may be taken as only suggestive as to the probable conditions in Porto Rico, and the local problems must be worked out here on the Island itself. In addition to working over parasitic fungi that have been studied by others, there are also constantly arising new problems more or less peculiar to this country.

The following report is intended to be a complete discussion of the cane fungi of Porto Rico, so far as they have been determined and so far as definite knowledge has been obtained regarding them. The report includes not only popular descriptions of the fungi, and the diseases which they cause, but technical descriptions of the important forms as well, since it is desired that the planters may be informed of the various destructive fungi present in their cane fields, and at the same time it is important that other workers in the subject may be in a position to know what fungi occur, together with the symptoms of the resulting diseases.

It is perhaps needless to say that there is still much to be learned about the cane fungi of Porto Rico, especially as regards problems of control, but nevertheless it seems eminently desirable at the present time to issue in one report such data as is available, inasmuch as



all the hitherto published data occurs as scattered notes in various publications, and many notes are here published for the first time.

The identification of the fungi mentioned in this paper has been accomplished with considerable difficulty, owing to the lack of the necessary literature and authentic specimens for comparison. The material, however, has been worked over and over for a period of nearly seven years, and it is believed that the specimens here reported actually represent the various species as designated and at least as they are commonly accepted. With regard to the new species named by the authors, such action has been taken to facilitate reference to forms of common occurrence which it has not been possible to connect with previously established names, although it is freely recognized that our scanty resources in the way of mycological literature may have resulted in some errors. It is held, however, that it is preferable to give a complete name to such fungi together with a description and illustration, than to merely refer them to their genera or leave them out entirely.

Between twenty and thirty other fungi, many of them of the family *Agaricaceae*, have been collected but are in large part omitted from the present paper, because of insufficient material for study. None are of any known economic importance, and for the most part have been collected but once. A list of these is given in so far as it has been possible to place them in the proper genera.

#### PREVIOUS WORK IN PORTO RICO.

In as much as the present paper is based upon investigations carried on since November, 1910, and as there have been no studies along this line in Porto Rico since that time, other than those of the authors' or than those carried out in cooperation with them, it will include the whole history of the study of cane fungi and diseases, if a short resumé of work prior to the above date is given, together with an account of the various publications issued from this Experiment Station since that time.

It has been difficult to obtain information either oral or published concerning the epidemic of 1872-80, although it is known to have been most severe. It was investigated by a commission of three members, including Dr. Agustín Stahl and a report issued in 1878 (1<sup>1</sup>). In spite of their earnest endeavors no cause was found and their principal recommendation was the introduction and cultivation of new and more resistant varieties.

<sup>1</sup> Figures in parenthesis refer to literature cited, page 238.

Some years later Don Manuel Fernández Umpierre (89) published an account of his observations and experiments for the control of the situation in his *Manual Práctico de la Agricultura de la Caña*. According to his statements the disease, if such it were, was completely controlled by thorough preparation of the soil, and subsequent careful cultivation with especial care to provide proper ditching. This latter detail was considered of great importance for the providing of a uniform moisture supply, avoiding the extremes of a water logged soil or a parched condition due to excessive drainage and evaporation in times of drought.

According to Massee (61) a cane fungus was sent from Porto Rico in 1878 to M. J. Berkely, who named the species in a letter *Darluka melaspora*. Cooke in publishing this species ascribes the fungus to Australia, which is considered an error by Massee. The identity of the fungus, whether with *Diplodia* or with *Melanconium sacchari*, is not positive but with little doubt pertains to *Melanconium*, although both fungi occur here.

With these exceptions there appear no available notes on the cane fungi up to the time of investigations by the staff of the Mayagüez Experiment Station. In 1903 Prof. F. S. Earle (21) of the New York Botanical Garden made a brief investigation of the insects and the diseases of the economic plants of Porto Rico in the course of which he encountered a sugar-cane root rot. He describes this disease (found between Yauco and Ponce) as one in which the young ratoon canes were very pale in color, almost milk white, and their growth very feeble. The old stubble and the base of the young cane was enveloped in a mass of white mycelium of some hymenomycetous fungus. No fruiting bodies were found on the stubble or young cane but specimens of a *Schizophyllum* were found and the suggestion is made that there may be some connection between the fungus and the diseased condition. On succeeding pages it will, however, be noted that what was seen by Prof. Earle was undoubtedly a case of chlorosis of cane together with one of the root fungi, presumably *Marasmius sacchari* or the stellate-crystal fungus, *Himantia stellifera*.

In the report of the Mayagüez Experiment Station for 1907 W. V. Tower (86) reported an outbreak of the rind disease (due to *Melanconium sacchari*) on the south side of the Island.

In the report for 1908 G. L. Fawcett (26) reported the sugar cane of Porto Rico as largely free from fungus diseases, with the exception of some districts on the east coast where there had been excessive rainfall. The canes in one field were found to be suffering much

from the attack of a soil fungus which was not identified. Slight attacks of the root disease were noticeable in many comparatively healthy fields in other parts of the Island. The rind disease was also present to some extent in some of the fields.

In the report for 1909, Fawcett reported "that root disease of cane caused by the attacks of various organisms is quite prevalent, especially on poorly drained fields of old ratooned cane. Two of the fungi reported as prominent in causing this disease, (*Marasmius sacchari* and the stellate-crystal fungus have been found. Up to this time the latter fungus has been noticed only on old leaf-sheaths, never on freshly decayed roots. \* \* \* The rind disease is common but as it is invariably found following the attacks of stalk-borers and does not affect plants except those already spoiled by these insects, it is hardly to be considered. For the pineapple disease which destroys the new planted seed cuttings, dipping of the seed cane in Bordeaux mixture is practiced on some of the large plantations with results reported as successful."

A bulletin (63) of the Mayagüez Station published in 1910 devotes a page to a general discussion of diseases of the sugar cane, stating that the root and pineapple diseases occur in Porto Rico, and referring the former to *Marasmius plicatus*, an error.

During the same year Mr. John R. Bovell, Superintendent of the Local Department of Agriculture of Barbados visited Porto Rico at the invitation of Guánica Centrale, confining his studies to the fields of that company. In his report (9) he lists the following diseases found attacking the cane:

Root disease.....	<i>Marasmius sacchari</i> Wakker.
Stem (red-rot) disease.....	<i>Colletotrichum falcatum</i> Went.
Pineapple disease .....	<i>Thielaviopsis paradoxa</i> (De Seynes) v. Holn.
Rind disease.....	<i>Melanconium sacchari</i> Mass.
Ring spot.....	<i>Leptosphaeria sacchari</i> v. B. de H.

A general discussion follows of the value of producing new seedling varieties, of the necessity of cleaning badly diseased fields of all infected material (the burning of trash is recommended), of the proper methods of cultivating, and of treating seed. The use of legumes, in particular of cowpeas, is recommended as well as the making of silage of cane tops. The report concludes with notes on the prevalence and symptoms of each of the diseases listed.

Work on the diseases of sugar cane was taken up at the Experiment Station of the Sugar Producers' Association of Porto Rico in November, 1910, as already noted, and the first report (45) of progress was published in the following year. This included a general



discussion of the subject of cane diseases and their treatment, followed by specific accounts of the more important diseases encountered, their symptoms, causes, and methods of control. Eleven diseases are so treated, root disease, rind disease, red rot, red spot of the leaf-sheath, red rot of the leaf-sheath, dry rot of the stalk, leaf spot, top rot, and chlorosis.

In the report of the next year (46) progress is reported in the field and laboratory studies of various fungi, and the results of preliminary experiments for the control of the various diseases are given.

The senior author presented before the December, 1912, meeting of the American Phytopathological Society a paper entitled "Notes on the Fungus Diseases of Cane in Porto Rico," an abstract of which appeared in "Phytopathology" (47). This paper listed some twenty-three species of cane fungi, not all of them completely determined, and gave some notes concerning their economic importance.

The third report (50) of the pathologist contained a list of projects then under way, including studies of root diseases, red-stripe disease, and field experiments for control of some of the other cane maladies. Two further publications (48, 51) issued at about this time deal in general with cane diseases and their control.

In the third report of the Board of Commissioners of Agriculture, issued at the time when the Sugar Experiment Station had been but lately turned over to their direction as the Insular Experiment Station, occurs a statement of projects, some of which concern sugar-cane fungi and diseases. Additional notes on the subject have been included in the fourth and fifth reports (74, 75) of the Board issued since that date, further mention of which will be made in the specific accounts to follow.

#### DISEASES NOT OCCURRING IN PORTO RICO.

While Porto Rico has its full measure of cane diseases, it is, however, fortunate, to the extent that quite a number of diseases serious in other parts of the world do not occur here. Foremost among these may be mentioned Sereh, the mysterious malady of Java and the East Indies. In some respects the mottling disease, or whatever term may be given the present epidemic, resembles Sereh without the distinguishing symptoms of the latter being present. It has in its progress to date, however, resulted quite as seriously as any Sereh attack could.

The gumming disease due to the action of a bacterium (*Bacterium vascularum* Er. Sm.) and present in New South Wales, Hawaii, and other parts of the world, is a serious cane disease not encountered



here. The iliau (*Gnomonia iliau* Lyon) of Hawaii and Louisiana is still another disease that has not reached the Island. Among minor maladies are the rust (*Uromyces Kuhnii* [Krüger] Wak. & Went), the smut (*Ustilago sacchari* Rabenhorst), an internal rot due to *Cephalosporium sacchari* Butl., black rot (*Sphaeronema adiposum* Butl.), and a number of leaf spots. No phanerogamic parasites have been collected.

A plant quarantine service was established in 1910 and cane cuttings brought to the Island since that time have been carefully inspected and treated. Many importations have been destroyed or planted in quarantine for observation. Through the continuance of this service it is hoped that Porto Rico will be spared the necessity of combating any new additions to the already long list of sugar-cane maladies.

#### DISEASES ATTACKING THE ROOTS AND BASE OF THE STALK.

##### THE ROOT FUNGUS (*Marasmius sacchari*).

*Marasmius sacchari* has been collected from practically all parts of Porto Rico, some of the determinations being based only upon the vegetative condition, but for the most part upon the fruiting bodies so that the determinations are to be relied upon. The sporophores are found commonly only in the rainy season when the ground and surface layer of vegetable matter are completely soaked. They occur both upon cane trash and upon the lower leaf sheaths of the standing cane.

This fungus occurs commonly only on fairly heavy or heavy soils, seldom on sandy soils. It is most abundant in low lands that are too heavy to plow with any convenience, or in land that has not been well plowed through neglect or other reason. It is found most abundantly in fields of ratoon cane, and the poorer the soil and the cultivation given, the greater is the damage from this fungus. Fields affected with chlorosis were examined to see if such a condition favored the development of the root fungus. In no case did there seem to be any correlation between chlorosis and *Marasmius sacchari*.

Examination has also been made many times of cane stools whose roots were injured by the white grub or the root weevil. Affected roots of this sort also usually show the root fungus. Supposedly the injury would give a free entrance to the fungus, but on the contrary, it is also true that the root fungus is common on roots not apparently injured by insects.

In connection with studies of the mottling disease, while con-

siderable root disease has been found, the lack of evidence of the presence of *Marasmius sacchari* in any amount, transfers the discussion to the account of the mottling disease itself.

*Injury.*—The injury caused is primarily upon the roots. The mycelium enters the roots, distintegrates the tissues and prevents a proper absorption of water and nutriment from the soil. As a result of this injury to the roots there is the secondary effect upon the development of the plant. According as the attack is sever or mild, the host shows a varying amount of leaf curling, a dwarfing of the stool, and often an early succumbing to less vigorous parasites such as *Melanconium*.

Injury to the roots can be ascertained by direct examination, a slow tedious process, or to a certain extent can be diagnosed by symptoms above ground. The fungus itself eventually appears on the cane above ground, growing within and upon the lower leaf-sheaths, some times one-half or two-thirds the height of the stalk. The external appearance is a white mycelial growth, which is conspicuous by its rather smooth membranous appearance in contrast to a distinctly filamentous growth. Tearing away the affected leaf-sheaths reveals the fact that they are decayed, and are glued together as it were by the membranous growth, to the underlying sheaths and the stalk. The decay of the lower leaf-sheaths may not in itself be of great importance, but the binding of the leaf-sheath to the stem is very undesirable from the point of view of the mill worker who prefers clean cane.

This fungus, like some others, appears to make great headway when once it has attained a strong foothold on the host. Thus the fungus may develop well on plant cane without doing appreciable injury, but may so increase its foothold on the ratoons as to do double the injury. As a result of this action it is a common sequence that plant crops are fair in certain localities, the first ratoon is considerably poorer, and the second ratoon often dies out completely. The damage may be restricted to one or a few stalks in a stool, or more commonly it may affect an entire stool as well as one or more adjacent stools to form the characteristic disease spots, or more rarely large portions of fields are entirely affected.

The injury to the plant may be considered threefold: the growth of the plant is checked often to the point where no merchantable cane is produced, the matter of clean cane is rendered difficult, and the cane becomes more susceptible to other diseases.

*Loss.*—To estimate the loss caused by a disease of this nature is always a complicated matter and for that reason usually highly unsat-

isfactory. Cane diseased with *Marasmius sacchari* may also be affected by poor soil, poor cultivation, drought, insect injury, and other fungi, and therefore to distinguish the injury done directly by the root fungus is almost impossible.

In general terms, some idea of the tremendous loss that may safely be attributed to this fungus can be given. In certain areas on the north coast in the district from Canóvanas to and beyond Río Grande, it is in some years impossible to obtain more than one ratoon crop, and in one large area the plant crop was a failure, largely owing to a decay of the roots due to this fungus. In a certain area of a few acres, in the Fajardo district in 1913, the plant crop refused to develop normally, at nine months of age appearing no larger than the normal cane at three months should. In adjacent areas in hill land third ratoons were a failure over several hundred acres.

On the south coast not far from Ponce in 1911, a large area of Otaheite cane failed to give a plant crop. Fields to a total extent of several hundreds of acres have been investigated (Report 1914-15) during the past two seasons in the Juncos, Fajardo, Toa, and Añasco districts where the cane had been practically destroyed by root disease, aided by unfavorable weather.

*Host Plants.*—In order to thoroughly work out control methods, it is essential to know on what plants other than sugar cane the fungus occurs, if any. *Marasmius sacchari* has been definitely collected on wild pineapple, (*Bromelia pinguin*), on the common *malojilla* or Para grass (*Panicum barbinode*), on *Andropogon bicornis*, and on rotting coconut husks. The sporophores were found abundantly on wild pineapple leaves that were still upright but badly diseased from some cause. The plants were heavily covered with vines creating a very damp situation. The material on the *malojilla* occurred in a similar situation. It is not, however, considered that the fungus was the cause of any disease on these plants, but rather that it was present as a mere saprophyte in which condition it is very common on cane trash.

*Occurrence in other countries.*—Lewton-Brain (55) gave the first description of the fungus in the West Indies, together with an illustration. Since then there have been many references to the occurrence of this fungus in various parts of the British Islands, and they may be found in the publications of the Imperial Department of Agriculture and of the various local departments. They include reports from Barbados, Trinidad, St. Vincent, St. Lucia, Dominica, Antigua, St. Kitts, Nevis, Virgin Islands, Grenada, and Monserrat. In British Guiana the disease was first definitely studied by Bancroft (7) although first reported by Stockdale. Bancroft's account deals

with the history, symptoms, and prevention of the disease which had in some districts proven serious.

The occurrence of the fungus in St. Croix, American Virgin Islands, is noted by Dr. Longfield Smith (68, 69) in his annual reports. It has been collected by the senior author in Santo Domingo.

Horne (39) reported in 1909 *Marasmius sacchari* as occurring in Cuba. He states that, "Vigorous first-year canes may have the lower leaf-sheaths matted together with fungus and show no sign of injury, while plants attacked at the root may not have the sheaths matted." Symptoms of the disease are rather fully described and recommendations are given for its eradication.

Root disease was first reported from Hawaii by Lewton-Brain in 1905 but was not definitely determined as due to *Marasmius sacchari*. Cobb (14, 15) reported a variety of *Marasmius sacchari* which he named var. *Hawaiiensis*. His description, however, agrees so well in detail with that of the West Indian material seen by the authors that it is believed to be identical with it, and typical of *M. sacchari* rather than a true variety. The damage done by the fungus is given as considerable.

This fungus has been described in several publications (90, 91) from the Javan Stations, and also in Kruger's "Das Zuckerrohr und Seine Kultur," and Wakker and Went's "De Ziekten van het Suikerriet op Java." Injury caused by this fungus was said to be serious in the seed beds and in the growing cane. The description of the Java fungus differs from that of the West Indian in a few details but it is generally understood at present that they represent the same species. *Marasmius* is given as the cause of one of the more important cane diseases of Mauritius by Stockdale (78).

*Description.*—As ordinarily seen in the field *Marasmius sacchari* is represented only by the white mycelium at the base of the stalks. During periods of rainy weather, however, the distinctive fruiting bodies also appear. These are small, more or less umbrella-shaped mushrooms, grayish-white in color, and growing near the base of the stalks on the outside of the leaf-sheaths. The top of the fungus varies from about one half inch to one and one-half inches in diameter.

The following is the technical description:

#### MARASMIUS SACCHARI Wakker.

Gregarious or fasciculate at the base, persistent, fleshy-membranous; pileus white, widely campanulate, then dingy white, plane or cup-shaped; 15 mm. diam.; lamellae white, simple or bifurcate; stipe central, white, 15 mm. long, tubiform at apex, villous at the base.



Hyphae white, sporidia hyaline, continuous, irregularly oblong, everywhere attenuate, rotundate, 16-20x4-5  $\mu$ .

PORTO RICO.—On cane, Ponce, June 8, 1911, 4062,<sup>1</sup> 4063; Fortuna, June 10, 1911, 4064; Río Piedras, Aug. 19, 1912, 4530, Sept. 19, 1912, 4597, Sept. 25, 1912, 4615; Canóvanas, Oct. 10, 1912, 4627; Mameyes, Dec. 3, 1912, 4691; Río Piedras, 1915, 3051, 3168. On *Panicum barbinode*, Cambalache, May 19, 1911, 4060; Patillas, Jan. 30, 1913, *D. L. Van Dine*. On *Bromelia pinguin*, Río Piedras, Nov. 12, 1912, 4730. On *Andropogon bicornis*, Río Piedras, May 30, 1914. On coconut husk, Santurce, Mrs. E. G. Britton, Feb. 12, 1914, 1471. Also collected a number of other times at Santa Isabel, Loíza, Carolina, Fajardo, Juncos, Camuy, Quebradillas, Toa Baja and Río Piedras. Of common occurrence in all parts of the Island. (Pl. XX, fig. 1; pl. XXVI, figs. 8, 9, 10.)

THE STELLATE-CRYSTAL FUNGUS (*Himantia stellifera*).

There is probably no form more common on cane in Porto Rico than the so-called stellate-crystal fungus which is commonly found at the base of the stalks, cementing together the leaf-sheaths, as do other species growing in this situation, and penetrating the roots as well. Although of such constant occurrence the question of its parasitism is as yet doubtful and will remain so until studies under controlled conditions of this form in comparison with other root fungi can be carried out.

Field observations have demonstrated its presence on a considerable range of plants other than cane, particularly those grasses which have a similar habit of growth. It has been found externally at the base of the following plants:

<i>Andropogon bicornis</i> *	<i>Paspalum plicatulum</i>
<i>Cymbopogon citratus</i>	<i>Paspalum schreberianum</i>
<i>Cyperus spicellatus</i>	<i>Paspalum underwoodii</i>
<i>Dichromena ciliata</i>	<i>Paspalum virgatum</i>
<i>Heliotropium indicum</i>	<i>Rynchospora cyperoides</i>
<i>Panicum laxum</i>	<i>Sporobolus jacquemontii</i>
<i>Panicum maximum</i>	<i>Stenotaphrum secundatum</i>
<i>Paspalum paniculatum</i>	<i>Syntherisma digitata</i>

The first mention of this fungus outside of Porto Rico is by Lewton-Brain (57) who described and figured it in connection with

<sup>1</sup> In the citations in this paper all collections up to September, 1913 (accession numbers 4000-5000) are by the senior author, those from that date until July, 1914 (accession numbers 1000-2100), are joint collections and all since that time, (accession numbers 2100-6500, omitting the 4000 series) by the junior author, unless otherwise stated. Specimens of all collections, except of some of the earlier numbers, are deposited in the herbarium of the Insular Experiment Station, Río Piedras, Porto Rico, and in so far as duplicate material was available in the herbarium of the New York Botanical Garden.

his studies on root disease in Hawaii. It was again mentioned by Cobb (15) in a succeeding Hawaiian bulletin. In neither instance was it named, although a possible connection with *Marasmius sacchari* was suggested. Bancroft (7) in British Guiana in reporting on a root disease which he attributed to *Marasmius*, mentions stellate crystals as one of the characteristics of the mycelium. What is apparently the same fungus was reported from Porto Rico by Fawcett (26), from St. Croix by Longfield Smith (69, 70) and from Jamaica by Ashby (3).

The presence of this fungus on other plants than cane suggests an error in the current method of combating root disease, the turning of the land to pasture. It will be much more effective to plant a legume (cowpeas or velvet beans), and so starve out the fungus.

### ***Himantia stellifera* Johnston sp. nov.**

Mycelium cob-webby, or somewhat dentritic, white, ascending the lower leaf-sheaths and penetrating the roots. Hyphae with clamp connections, and bearing on short side branches stellate crystals of calcium oxalate. No fruiting bodies known.

Differs from *Himantia sacchari* Speg. and *Himantia guttulifera* Speg. in the presence of the stellate crystals as well as in other essential points.

PORTO RICO.—On cane, Río Piedras, Jan. 12, 1914, 1183, (type); Juncos, Aug. 23; 1915, 3050; Cambalache, March, 1914, 5136. On *Cymbopogon citratus*, Río Piedras, Oct. 26, 1914, 2282, Oct. 1915, 3212. Collected or observed on cane and many other hosts commonly in all parts of Porto Rico. (Pl. XIX, fig. 2; pl. XXXI, figs. 1-4.)

### THE GRANULAR LEAF-SHEATH FUNGUS (*Odontia saccharicola*).

This is a very common fungus occurring at the base of cane stalks binding, (as is usual with fungi of this nature) the lower leaf-sheaths firmly together and to the stalk itself as well, so as to make their removal difficult. Whether or not the fungus penetrates below ground to the extent of attacking the roots is a point which it has not yet been possible to investigate. The only visible damage is the rotting of the leaf-sheaths which are permeated by the white mycelial elements. Fruiting areas occur as uniform thin white patches with a granular somewhat powdery surface encircling the stalk from the ground level to a height of eight inches or a foot. (Pl. XIX, fig. 1.)

This fungus is very commonly found on all varieties of cane and occurs apparently independent of whether the stool is healthy or otherwise. It is very common on canes attacked by the mottling

disease but no more so than the canes in the Experiment Station fields. In all studies of root disease made heretofore, however, this form has been beyond much doubt confused with other forms present, and the presence of root disease has been assumed where it occurred.

This form may easily be confused with the much less common species *O. sacchari*, which is treated under minor fungi. To quote Dr. Burt, "*O. saccharicola* is thinner and is composed of shorter-celled hyphae which are not suberect, not nodose-septate and do not bear spores in the interior of the fructification. The stellate crystals are present abundantly in all specimens \* \* \* and appear to be of aid for recognition of this species."

ODONTIA SACCHARICOLA Burt, Mo. Bot. Garden 4, No. 3, 1917.

Fructification resupinate, effused, adnate, very thin, pulverulent, not cracked, whitish, drying cartridge-buff, the margin narrow and thinning out, granules minute but distinct, about 6-9 to a  $\mu\text{m.}$ , in structure 30-50  $\mu\text{m.}$  thick with the granules extending 45-60  $\mu\text{m.}$  more, composed of loosely and somewhat horizontally arranged branched, short-celled hyphae, 2.5-3  $\mu\text{m.}$  in diameter, not nodose-septate, not incrustated but having in the spaces between hyphae numerous stellate crystals 4.5-7.5  $\mu\text{m.}$  in diameter from tip of ray to tip of opposite ray, cystidia hair-like, flexuous, not incrustated, septate, weak, often collapsed, tapering upward to a sharp point, 1.5-3  $\mu\text{m.}$  in diameter, protruding 8-18  $\mu\text{m.}$ , about 1-3 to a granule at the apex; basidia simple, cylindric-clavate, with 4 sterigmata; basidiospores hyaline, even 5.5 X 5.5  $\mu\text{m.}$ , flattened on one side. *Dr. Burt's description.*

PORTO RICO.—On cane, Vega Alta, July 5, 1912, 4525; Río Piedras, Jan. 9, 1914, 1172, Jan. 13, 1914, 1184, Jan. 1915, 2657-a, Oct. 5, 1915, 3176, Dec. 1915, 3617, Feb. 9, 1917, 6193, July, 1917, 6589; Canóvanas, June, 1916, 5502. Also observed at Juncos, Toa Baja, Camuy, Quebradillas, Arecibo, and Fajardo. Very common everywhere. Original determination by Dr. Burt, 1916. (Pl. XIX, fig. 1.)

The exact status of root disease with respect to the parasitism of *Marasmius*, *Himantia*, *Odontia*, or possibly other forms is uncertain and while it is generally held that *Marasmius* at least is a true parasite, really definite evidence is lacking. Studies under controlled conditions must be carried out working with pure cultures of the fungi, which has not yet been possible. As is the case with so much of the work in tropical pathology to date, root disease studies of a necessity have consisted of field observations only, valuable in as far as they go, but hardly to be used as a basis for exact determinations of matters of parasitism.

It has been suggested, and it is believed with good basis, that *Odontia saccharicola* is the perfect stage of *Himantia stellifera*. This possibility affords a further point to be included in the above proposed investigations. The presence of stellate crystals in the fruiting bodies as reported by Dr. Burt affords further evidence of such a connection.

The need of a greenhouse (a lack which has now been remedied) from which wind and insects can be excluded and where moisture supply and other factors can be controlled to a large extent has been one reason preventing careful studies of root disease up to this time. Pot cultures in the open have proven very disappointing, and more often than not complete failures.

#### ROOT-KNOT (*Heterodera radiculicola* [Greef] Müll.)

While not due to the work of a fungus, some mention of root-knot for the sake of completeness is desirable in a paper of this nature. Although a considerable number of economic plants suffer from nematode attack in Porto Rico (75, 76) particularly some of the vegetables, cane in so far as observed suffers but little. In one instance a considerable amount of infestation was found in 1915 in certain fields near Juncos which were suffering from unfavorable weather conditions, and a rotting of old stools (root disease). So many conditions were involved that it was impossible to say as to whether the nematodes were playing any large part in the destruction of the cane. In experimental plantings artificially infested by burying typical root-knot material from *Coleus*, only slight infestations resulted. Root-knot apparently does not threaten any great amount of harm to cane in Porto Rico. Other species of nematodes have not been encountered.

PORTO RICO.—On cane, Juncos, July 29, 1915, 2934; Río Piedras, 1917. Also collected on a wide range of other hosts, reported in other publications (75, 76).

#### DISEASES OF THE STALK.

##### THE RED ROT (*Colletotrichum falcatum*).

The red rot or red smut as it is known in Java can hardly be considered as one of the serious cane diseases of Porto Rico, although the fungus causing it is one of the most common forms encountered, usually as a saprophyte. As a parasite it attacks the stalk and leaves causing in the first instance an internal red rot, and in the second



a red stripe of the mid-rib. This latter phase is discussed in detail under leaf diseases.

*Occurrence in other countries.*—*Colletotrichum falcatum* was first reported and described from Java in 1893 by Went (93, 94), and has been treated in great detail by Wakker, Went, and other workers (53, 97, 98), in that country, where it is considered one of the most serious of cane diseases. Its parasitism was proven by inoculations and life history studies were carried out.

The disease has been of equal, if not greater importance in British India and in fact a perusal of the literature leads to the conclusion that it is far and away the most serious cane disease of that part of the world. Butler (10, 11) has carried out extensive and conclusive studies with this disease, although the first report was by Barber (8), who noted that the disease was apparently parasitic in one district and saprophytic in another. Butler's investigations led him to believe that the fungus was readily transmissible from cutting to shoot, and that this was the chief method of infection of growing cane.

Lewton-Brain (59) gave a complete account of the disease reporting, however, that in Hawaii it was of little importance.

In the southern United States, Edgerton (23, 24, 25) has investigated red rot in Louisiana and reports finding a loss in stand due to the killing of young plants and decrease in per cent of sucrose through inversion by the action of the fungus. Fawcett (27, 28) reported the fungus from Florida and the senior author has observed it in Florida, Georgia, Louisiana, and Texas.

Considerable work has been carried out with this fungus in the West Indies. Howard (43, 44) in particular conducted studies with it, maintaining that it and not *Melanconium* was the cause of rind disease. He describes the disease as follows: "The disease appears about four or five months before the canes are cut, generally at the beginning of the ripening period. \* \* \* The first outward symptom of the malady is the drying up of the leaves which commences at the margins of the older ones, and gradually spreads to the center of the tuft in from four to six weeks. When this drying of the leaves is well marked, the stem of the cane shows a brown discoloration in one or more places, after which the rind shrivels up, and the discoloration rapidly extends in all directions. On splitting such canes, the tissues are seen to be of a reddish color, in which darker red areas can be seen. Very frequently these darker regions contain definite white centers, elliptical in vertical section."

South and Dunlop (72) present a review of the literature and the results of inoculation experiments carried out by them in Barbados

and St. Kitts. They concluded that the fungus is merely a facultative wound parasite, gaining entrance largely through borer holes, and that the disease was not communicated by infected cuttings.

In addition to the above there are reports of occurrence by South (70, 71), Ballou (4), Nowell (64, 65), and Dash (18), in Barbados, Antigua, St. Kitts, and St. Lucia. The senior author reported (49) it from Santo Domingo. It is mentioned by Averna Sacca (100) as one of the cane diseases of Brazil.

Tryon (87) mentions red rot as one of the cane diseases of Queensland and Stockdale (78) in reports of the agricultural department of Mauritius gives an account of its occurrence on that Island.

*Red Rot in Porto Rico.*—The losses due to this fungus in Porto Rico in no way compared with those reported from other countries. It is of interest to note that this fungus, which occurs in most cane countries, varies greatly in its virulence as indicated in the discussion above, Porto Rico being one of the regions in which it is for the most part a wound parasite only. In a very few instances it has, in connection with a lack of water, destroyed cane over small areas, one field of less than one hundred acres being the only serious case observed. There are indirect losses through a decrease in effective leaf surface, and through its growth in connection with borer injury, or *Melanconium* and other fungi, but these are of such a nature that it is impossible to give any estimates.

The fungus very commonly occurs in stalks injured by the moth stalk-borer (*Diatraea saccharalis*) or other causes, producing a red discoloration internally, but no external symptoms, at least as long as the cane remains green. Development of the fungus may be fast or slow according to the variety and the vigor of the cane. The damage caused is, however, more than is apparent since the fungus very quickly inverts the sucrose to a considerable extent, raising the glucose ratio. The relation of *Colletotrichum* to the inversion of sucrose has been considered by all of the various workers who have investigated the matter to any extent, and all have agreed that this represents the serious phase of the disease.

To a more limited extent, the fungus occurs independent of borer holes but it is generally possible in such instances to find some other weakening influence, drought, root disease, or other fungi. It frequently happens that young shoots are crowded out by more vigorous ones in a stool and wither away, and in such cases this fungus may commonly be found, although, even then, the moth-borer, or other insect or root disease may be the initial cause. Where large areas of cane are attacked it has generally been found that there have

been pre-disposing causes, particularly drought. *Colletotrichum* is often found following after the rind disease, that is in so far as external appearances show. As to which is primary internally appears to be immaterial, sometimes one appearing first and sometimes the other. Both are considered wound parasites or as capable of attacking weakened canes only. A further note on the occurrence of this fungus will be given under "Diseases of Cuttings."

There are other forms which are morphologically similar to *Colletotrichum falcatum*. For this reason the finding of what is supposed to be *C. falcatum* on other plants should be demonstrated by cross-inoculations. It has not as yet been proven that this fungus does occur on other plants. Edgerton (25) has attempted by cross-inoculations to ascertain whether *C. lineola* on Johnson grass (*Holcus halepense*) may not be the same as *C. falcatum* on cane, as it appears to be morphologically, but as yet he has been unsuccessful in this.

Although not definitely proven to be *C. falcatum* a form identical with it in appearance has been found on dead leaf-stalks of the common papaya (*Carica papaya*). As a matter of fact more than one form has been found on cane, as is noted on another page, and until more is known about the relationships of these various forms the question of the occurrence of *C. falcatum* on other plants can not be satisfactorily determined.

*Description of Colletotrichum falcatum.*—The fungus produces an internal red rot of attacked canes, often limited in otherwise healthy stalks to the injured internodes only, but in more severe cases progressing up and down the stalk, more rapidly along the vascular bundles than in the surrounding tissues. After the rot has progressed some time characteristic whitened spots appear in the center of the red areas. Beyond a withering of the leaves no other symptoms are present. The fungus does not fruit until the stalk has become dead and thoroughly rotted, when it produces black velvety patches on the surface more generally near the nodes. It is very common to find the fungus fruiting on dead leaves, or on the margins and tips of leaves which are dying.

#### COLLETOTRICHUM FALCATUM Went.

With setae sometimes seriate, sometime congregate in a pseudo-conceptacle, 100-200 X 4  $\mu$ ., sooty, pale above; conidia falcate 25 X 4  $\mu$ ., at the base of the setae supported by basidia, ovoid, 20 X 8 microns, hyaline or dark.

PORTO RICO.—On cane Río Piedras, April 10, 1911, 4050, April 21, 1911, 4055, June 5, 1911, 4068, April 20, 1912, 4336, May, 1912,

4334, 4342, May, 1912, 4351, Feb. 3, 1914, 1342, Nov. 28, 1916, 5816, Feb., 1917, 6313, 6403; Ponce, Jan. 11, 1912, 4150, 4155, 4160; Fortuna, April 27, 1912, 4356; Fajardo, March 25, 1912, 4292; Yauco, March, 1912, 4299, 4300; Canóvanas, May 29, 1912, 4343; Carolina, Jan. 9, 1915, 2521. On *Carica papaya*, Río Piedras, Oct. 24, 1912, 4645, Dec. 1912, 4731. Common in all parts of the Island on dead and dying cane stalks and leaves. (Pl. XX, fig. 4; pl. XXVIII, fig. 9, 13, 14, 16, 17.)

#### RIND DISEASE (*Melanconium sacchari*).

The rind disease of cane has been the subject of a paper recently published in this JOURNAL (52) and was there treated in such detail as to make it unnecessary to give more than a summary for the sake of completeness in the present account.

Rind disease has been reported and studied under a variety of names and with much confusion with other fungi, (in particular with *Thielaviopsis*), in practically all of the cane growing countries of the world, including Louisiana, Georgia, Texas, Florida, Cuba, Jamaica, British Guiana, Barbados, Trinidad, St. Vincent, Antigua, Grenada, St. Lucia, Nevis, Argentina, Brazil, Mauritius, Java, Indo-China, Queensland, New South Wales, and Hawaii. In some instances it has been considered as a serious parasite, and in particular has been held to be the cause of a serious epidemic of disease which nearly destroyed the cane industry of Barbados in 1895-99. Most workers are now agreed, however, that as a general rule *Melanconium* is but a wound parasite or an enemy of weakened or over-mature canes. This view is held for Porto Rican conditions where it is one of the commonest, if not the commonest fungus present in the cane fields.

Circumstances under which the rind fungus have been noted in Porto Rico are extremely variable. It has never been observed in fields of young green cane excepting in shoots injured or killed by some other fungus such as *Marasmius sacchari* or by such insects as the changa, white grub, or the moth stalk-borer. In such cases it is certainly only a saprophyte.

In cane of six or eight months, it can commonly be found on the leaf-sheaths of many stalks and especially on certain varieties. The fungus occurs not only at the base on the outside of the leaf-sheath but occasionally near the union of the leaf-sheath with the leaf-blade. On the leaf-sheaths it may hasten the dying of the leaf but does not necessarily pass from the sheath into the stalk. Numerous canes have been watched to maturity, which remained perfectly healthy as far



as the stalks were concerned, but which had had the fungus on the leaf-sheaths for some months.

In contrast to these conditions, damage which can be attributed to *Melanconium* has been observed, where weak varieties or over-mature cane was involved. A variety known as D-625 has been particularly noted suffering with typical rind disease, moth-borer or other fungi not being present in sufficient amount to account for the loss. It has also been a common experience to have fields, which had been left over from one crop season to the next, either because it was hoped the yield would be increased, or because it was impossible to cut them before the grinding season closed, destroyed or rendered worthless as far as the yield of sugar was concerned. Rayada, white (Otaheite) and D-625 have been noted suffering in this manner.

In addition to attacking over-mature cane, it is not uncommon to be preceded by a weakening of the vitality of the cane through the presence of the root disease, or some untoward soil condition. This is especially true in old ratoons that are "running out," and instances have been seen where such a state of affairs resulted in total loss.

In all cases in Porto Rico an infection with the rind fungus seems to be preceded by a weakening of the vitality of the cane through some other unfavorable condition. Unfortunately these conditions can not always be foreseen, and therefore rind disease must be considered as something of an obstacle to continuous good yields in spite of its lack of a truly parasitic nature. In general, however, the use of hardy varieties, not allowed to become over-mature and properly cultivated, will avoid any serious loss from this malady.

The fungus will be further considered as a disease of cuttings under that heading.

*Description.*—The fungus produces a souring of the juice and a soft white rot of the tissues, affected stalks withering and drying up. Fruiting pustules form in great numbers on thoroughly rotted stalks or on the base of leaf-sheaths, appearing first as small black slightly raised areas, several times longer than broad. The epiderm covering these is soon ruptured permitting the black spore mass to exude which, depending upon the moisture present, varies in shape from a flattened mass to long thread-like processes.

#### MELANCONIUM SACCHARI Masee.

Conidia produced in pycnidia (acervuli) formed under the epidermis, unicellular, pale brown, cylindrical, straight or curved, 14–15 X 3.5–4  $\mu$ .; conidia extruded in long black cirrhi.

PORTO RICO.—On cane, Yabucoa, March 27, 1911, 4040; Río Piedras, April, 1911, 4052, 4056, June 5, 1911, 4066, Feb. 10, 1912, 4211, March 25, 1911, 4295, April 14, 1912, 4340; Fortuna, April 27, 1912, 4356; Jan. 10, 1912, 4152; Aguadilla, April 7, 1916, 5135; Camuy, Jan. 4, 1917, 6074. Very common in all parts of the Island. Observed but not collected at Fajardo, Canóvanas, Carolina, Juncos, Arecibo, Barceloneta, Central Alianza, Quebradillas, Utuado, Isabela, Añasco, Guánica, Vega Baja, Toa Baja, Bayamón. (Pl. XX, fig. 3; pl. XXXI, fig. 7.)

#### CYTOSPORA SACCHARI.

This is a comparatively new disease of cane for which no common name has as yet been proposed. It was first found in February, 1912, by the senior author on dead cuttings of various Barbados seedlings at Río Piedras. In succeeding months it was noted on dead stalks of other varieties of the same origin, and in 1913 was discovered at Fajardo, again on Barbados seedlings. In this instance, it was causing some loss. Still later investigations were made in this locality, the disease having spread to other varieties and occasioned some alarm. The only other locality in which the fungus has been seen to date is Carolina where in 1914 a small infected area in *rayada* (striped) cane was observed. The varieties which have suffered injury have been the softer white canes and for the most part introduced varieties. It would appear that the disease had been brought in on some one of these prior to the establishing of the plant quarantine.

The following varieties have been found infected to date, Rayada, B-7169, B-6385, B-1753, B-8660, B-7245, B-3696, B-3859, B-1355, B-3922, D-109, D-117, G. C.-759, and G. C.-47. Of these B-3922 and B-3696 have been most severely attacked.

The first report of the occurrence of *Cytospora* is from British India. Butler (10) who originally described the fungus stated that "on one stool examined the stem at one of the upper internodes was affected and the fungus was present on the leaf-sheaths as well." For the most part, however, it was merely a saprophyte. Avena-Sacca (100) has recently given an account of a disease which he ascribes to this same fungus, occurring in the State of São Paulo, Brazil. He claims to have found the perfect stage, but without having made any pure culture studies. His results are considered very doubtful.

The symptoms of the disease are very marked. Young shoots are killed outright, others checked in their growth, and the lower

leaves prematurely killed. The leaf-sheaths are bound firmly together by the mycelium, so that the shedding of the lower leaves one by one as occurs normally with most varieties or at least their loose adherence to the stalk only, does not take place. The leaf blades bend over at the junction with the sheath and hang parallel to the stalk giving diseased stools a most characteristic appearance. All exposed portions of leaf-sheaths are a very dark dull red, darker than the color produced by *Cercospora vaginæ*, as well as more uniform as to area covered. The orange-red discoloration produced by *Sclerotium Rolfsii* could hardly be confused with it, even if sclerotia were absent. The reddened area is profusely covered with the fruiting bodies, the comparatively long pointed necks of which project beyond the surface sufficiently to be readily seen, and to give a rough sensation when the finger is rubbed over them. During wet weather a minute yellowish globule of conidia can be seen with a hand lens, exuding from the mouth of the beak of each pycnidium.

A more serious effect of the fungus is its attack on the stalks of certain susceptible varieties. Young stalks are very quickly killed and in fact those of some size are often overcome, in particular any that have not formed any hardened internodes. The fungus produces a dry rot which of course renders the cane worthless for sugar production. On canes which are mature or nearly mature, very typical cankers or lesions are produced. These may be one, or several on each internode, and they are often confluent so as to completely encircle the stalk. Infection apparently occurs through the leaf traces from infected leaves since the lesions in practically every case commence at the nodes and spread downward along the internodes. One or more infections may occur at each node, but never extend over more than one internode except in advanced stages, where fusion of the separate diseased areas occurs. An exception to the manner of entrance of the fungus occurs along cracks, which are commonly present in the soft white varieties. Nodal infections take on a very characteristic shape, that of an inverted cone with a blunt point, the broad base lying along the node, and the point extending down toward the node below. The diseased areas have regular margins except toward the apex and are a deep brown in color, lighter toward the lower end. The most advanced portions present merely a water soaked appearance of the tissues. The lesions are slightly sunken in the older portions, or near the nodes, and along any cracks that may appear. The cracking in itself is not considered a symptom since it is a phenomenon which occurs naturally in many varieties and also accompanies a number of other diseases. The brown coloration ex-

tends into the tissues a short distance only, rarely more than an eighth of an inch. Rind disease very often completes the destruction of the attacked stalk.

Because of the fact that this fungus, a saprophyte only in other parts of the world, was acting as a virulent parasite in Porto Rico towards several varieties, fears were entertained that it might become epidemic. However, there has been in the past year no further spread and it would appear that the disease had reached its limit. The susceptible varieties growing at Río Piedras have been eliminated and there are at present no signs of the fungus. A similar procedure was recommended for the other localities known to be infected.

#### CYTOSPORA SACCHARI Butler.

Stromata verruciform, arranged in rows, erumpent, plurilocular, black, ostiole elongate, single, rarely double; sporules minute, cylindrical, slightly curved, obtuse at both ends, 3.5 X 1-1.5 mu.; basidia branching, septate, 12-18 mu. *Description after Butler.*

PORTO RICO.—On cane, Río Piedras, Feb. 1912, 4280, May 24, 1912, 4352, Aug. 1912, 4335, July 10, 1912, 4656, Jan. 15, 1914, 1646, Oct. 1915, 3217; Carolina, Feb. 18, 1914, 1408; Fajardo, July 6, 1913, 4983, Aug. 4, 1913, 1012, Dec. 30, 1914, 2526, June 14, 1915, 2829, Dec. 27, 1916, 5907. On leaf-sheaths, and stalks of living cane. Pl. XXII, figs. 1, 2; pl. XXVIII, figs. 1-4.)

#### TOP-ROT.

This is a term that has been employed to some extent in the literature and is used by a great many planters to indicate a diseased condition of the top. Considerable attention has been given to this disease in Porto Rico but up to date it has not been possible to arrive with any certainty as to the cause. When a stalk is badly injured by the moth stalk-borer, the top ultimately dies and in the rotten mass at the center will be found small borers, fly larvae, etc. This is the most common type of top-rot found in Porto Rico, and is clearly due to the borer. It is, however, quite possible to find dead tops or "dead hearts" as they are called locally, which do not show any signs of insect work. In fact a former entomologist of this Station in the course of his studies of *Diatraea* reported that a considerable proportion of "dead hearts" examined by him were not due to the borer. Cultures of such cases have yielded bacteria and several types of fungi, none of which have produced any results upon inoculation.

The senior writer observed a plantation in Texas in which the



cane was growing poorly, and where the stalks with dead tops were very numerous. The dead tops showed at the heart a soft white putrid mass indicating a bacterial rot. Borers were present in the stalks but not in the tops.

Top-rot has been reported in Java but no definite conclusions were reached as to its cause, nor was it clearly diagnosed as a specific disease.

#### DISEASES OF THE LEAF.

##### THE RED SPOT OF THE LEAF-SHEATH (*Cercospora vaginæ*).

The red spot of the leaf-sheath is an extremely common disease of many varieties of cane, so much so in fact that the reddening of the lower leaf-sheaths becomes almost a distinguishing character of some types. Infection occurs on the upper sheaths while they are still green and closely appressed to the stalk. The areas are at first quite regular in shape, bright red in color, and sharply set off from the normal green tissues surrounding. They increase in size rapidly, becoming irregular in shape, and finally cover the larger portion of the sheath. The fungus not only spreads over a given leaf-sheath but invades those beneath, the area attacked on each successively becoming smaller and smaller as it passes toward the center. However, several to many points of infection may be set up on each sheath. This action is sufficient to insure the spread of the disease to all the leaves of any one stalk. The leaf blades have not been found subject to attack. Occasional lesions ascribed to this fungus are found on the stalks. Fruiting areas occur as black patches often several inches in diameter at the center of the infected regions of the outer sheaths.

This disease has been reported from the West Indies by Bancroft (5, 6), from Java by Wakker (92), and by Kruger and Went (53), and from Reunion by Colson in his work on the sugar industry of that island.

As is the case with so many leaf diseases it is somewhat difficult to make any definite statements as to the amount of damage caused. It ordinarily passes without notice, and is in fact considered a natural phase of the growth of the cane by most planters, but it is certain that it is responsible for some decrease in sugar content because of its action in bringing about a premature death of the leaves.

Such experiments as have been carried out during two seasons were contradictory. In the experiment of 1911, cuttings of *Cristalina* cane were used, all badly diseased. One hundred of these were

planted without the removal of the diseased sheaths and two hundred were planted after stripping. The germination was as follows, counting shoots per hundred seed, the planting being made March 27:

	April 17	April 24	May 1	May 13	May 24
Sheaths removed .....	13	64	104	156	158
Sheaths not removed.....	69	167	206	229	241

This apparently showed that better germination followed non-removal and that red spot did no injury. In the mature cane of this planting there was no difference in the respective amounts of the disease present.

In the experiment of 1913, three hundred seed with the leaf-sheaths on and three hundred with them removed were planted in alternate rows of one hundred and fifty seed each. At the end of the counts of the germination, the two rows planted with the sheath on gave seven hundred and eight shoots, the other two rows one thousand and three, a result exactly opposite to that obtained the first year. In the latter experiment the leaf sheaths may have presented a mechanical obstruction to germination. The use of a different variety (Otaheite) may also explain the difference in part. Subsequent growth showed no observable difference in the amount of disease present on the two lots.

There is a very marked varietal resistance to the fungus. *Cristallina* and B-1753 are usually badly affected, Otaheite somewhat less and yellow Caledonia, D-116, and the red or purple canes such as *cavengerie*, etc., are seldom much infected. It can not be determined that the amount of infection shows any definite relation to the so-called hardiness of the variety. No environmental conditions have been noted which appeared to have any connection with the amount of disease present.

#### CERCOSPORA VAGINAE Krüger.

Hyphae dark, cobwebby, arising from the center of a red discoloration on the leaf-sheath; sporophores more or less erect, rigid or flexuous at the tip; spores solitary usually at the tip, occasionally borne on the side of the sporophore, one to several celled, 4-8  $\mu$ . x 15-40  $\mu$ .

PORTO RICO.—On cane leaf-sheaths, Río Piedras, March, 1912, 4293, 4296; Los Caños, Dec. 8, 1911, 4118; Fajardo, March 25, 1912, 4290; Arecibo, March, 1916, 5088. Observed in all parts of the Island, on practically all varieties of cane. (Pl. XXIX, fig. 19, 20; pl. XXIV, fig. 1.)

## RED ROT OF THE LEAF-SHEATH (*Sclerotium Rolfsii*).

This is again one of the diseases of cane which, though very common everywhere, has not been considered of economic importance. In fact there have been no observed cases of serious loss in cane fields attributable to this fungus in Porto Rico, although such instances have been reported from St. Croix and Georgia.

The fungus favors the more moist situations and apparently heavier soils. In cane fields it does not appear to any extent until the cane has closed in creating a moist situation. Upland fields show but little of the fungus, except in wet weather. It is not uncommon to find fields practically every stool of which shows an abundance of infection. It has not been possible even in such cases to observe that any damage was being done, the stand apparently being entirely normal. Young shoots will be commonly found dead and covered with the sclerotia, but the death of these young shoots occurs under all conditions and is considered a natural phenomenon due to smothering or lack of light or food. The lower leaf sheaths are undoubtedly prematurely killed, but since the fungus rarely attains to any height on the stalk the leaves so destroyed are those already shaded and hence rendered more or less useless, so that the injury due to reduction of leaf surface is considered negligible. Whether the fungus attacks the roots as it does those of other hosts is not known. This is a point which must be taken up along with a detailed study of the root disease fungi.

The fungus appears as a white, more or less feathery mycelium growing up the lower leaf-sheaths binding them together and producing a red rot of the infected tissues. The color of the rot is a bright orange-red quite distinct from that of *Cercospora vaginæ* or of any other disease attacking at this point. The areas are very irregular, with indistinct margins, seldom extending over a foot or a foot and a half above the ground level. The only fruiting stage known consists of the sclerotia produced particularly along the edges of the leaf-sheaths, in the folds, or between two diseased sheaths and to a less extent on the reddened areas of the outer surface. They are first noticed as white, very small, masses of hyphae forming on the strands of mycelium. They finally become from one thirty-second to a sixteenth of an inch in diameter, more or less spherical, flattened at the poles. The color varies from white through yellow-brown to a very deep red-brown or brown, when mature. The sclerotia when mature are quite firm and but loosely attached to the substratum.

This fungus has been observed (76) as the cause of a serious wilt disease of various vegetable crops, particularly the egg-plant, pepper.

and tomato. It has been found causing a damping off of citrus seedlings and doubtless attacks a range of other hosts here, many others being reported from the Southern United States.

As a disease of cane *Sclerotium Rolfsii* was first studied and described from Java by Krüger (53). Howard (44) has reported it in Trinidad and Longfield Smith (70) in St. Croix. Mention of its occurrence is also made by Horne (39) in Cuba and Ashby (3) in Jamaica. The senior author has seen it in abundance in Florida, Georgia, Louisiana, and Texas.

PORTO RICO.—On cane, Hormigueros, July 17, 1911, 4070; Río Piedras, September 18, 1915, 3078, June, 1917, 6560. Observed in all sections of the Island. Also collected on *Lycopersicum esculentum*, *Capsicum annuum*, *Solanum melongena*, *Citrus* sp. (Pl. XXV, fig. 3.)

#### THE EYE-SPOT OF THE LEAF (*Helminthosporium sacchari*).

The leaf blades of the sugar cane are subject to a number of diseases, so commonly in fact, that a field of mature or nearly mature cane that does not show a large per cent of infected leaves is a rarity. Several fungi are concerned in producing the spotting, some more common in one section, others in other parts of the Island. Certain districts suffer much more than others, the Fajardo area for instance being much more free of leaf disease than some others. It is difficult if not impossible to make any statements as to the losses occasioned by these diseases since their effect is indirect. There is undoubtedly some loss due to the destruction of leaf surface, the amount varying with the per cent of infection, and the age of the cane when attacked. The exact relationships of the various fungi and resulting leaf spots have not been completely worked out, but such notes and observations as their economic importance warranted have been made.

One of the common types of leaf-spot is that called by some workers the "eye-spot." Several varying forms have been encountered, doubtless due to the varietal differences of the host or environmental factors. That most generally noted was one encountered very commonly in studies of the mottling disease in the Arecibo-Aguadilla region. The spots were a medium to dark brown in color, with definite margins, much longer than broad, from one to five millimeters in breadth, from one to five centimeters in length, very numerous, often coalescing, and very often the apparent cause of death of the leaf. In other instances the spots are elongate-oval not coalescing, or causing death of the leaf, medium brown in color, 2-4 mm. by 8-15 mm. Still a further type was encountered in which the spots were oval, about one by two centimeters, distinctly zoned, with a rather indefinite



margin, and yellowish brown in color. It has been observed on T. 77, Otaheite, Rayada, Sarangola, and in fact all varieties growing in the western end of the Island.

*Helminthosporium sacchari* has been reported (generally as *Cercospora sacchari*) from Hawaii (54), the Philippines by Barrett in 1911, Java (53, 93), Reunion, and British India (12). It was originally described by Van Breda de Haan and redscribed by Butler who placed it in its present genus. By none of these workers has any serious damage been attributed to it.

HELMINTHOSPORIUM SACCHARI Butler.

*Cercospora sacchari* Van Breda de Haan.

Hyphae dark, cobwebby, arising from the center of an elongate brown spot on the leaf-blade; sporophores more or less erect with single terminal spores; spores several septate with very thick walls, rounded at both ends, 32-90 X 9-14 microns, on conidiophores 120-160  $\mu$ . long.

PORTO RICO.—On cane leaves, Río Piedras, January 22, 1914, 1642, April, 1917, 6418, June, 1917, *R. C. Rose*, 6550; Camuy, Jan. 4, 1917, 6078; Quebradillas, December 1916, 5900. Original determination by J. A. S. (Pl. XXIX, fig. 4, 5.)

RING SPOT OF THE LEAF (*Leptosphaeria sacchari*.)

This is one of the most common cane fungi of Porto Rico. It is found in practically all cane fields, being usually most abundant on the windward side. Practically every variety will show some infection, although there is great variation in susceptibility, yellow Caladonia and the white bamboo for instance being quite free as a rule. The amount of disease present also varies in different sections of the Island. Some loss is occasioned by destruction of leaf surface, and in connection with poor growing conditions, or other weakening influences, there may be a heavy loss.

The spots produced by this fungus are usually very numerous, oval in outline, 5-10 millimeters in breadth by 7-15 in length, dull gray at the center with a definite red or red-brown margin several millimeters in width. There is often an indistinct yellow halo surrounding each spot. The spots not only have a tendency to coalesce but the tissue between turns yellow and the entire leaf as a result withers. This action, however, takes place slowly. Conidia are produced on the lower surface of the spots, obtuse angled, black, 3-5 septate, the central or two central cells being larger than the apical

ones. The perithecia appear as minute black immersed bodies at the center of old areas.

The disease was first described by Van Breda de Haan in West Java and was later treated in some detail by Wakker and Went (93). Butler gives an account of the disease as it occurs in British India (10) and Cobb (15) makes short mention of its presence in Hawaii. It has been reported several times from Cuba (38, 39) and is known to be present in the British West Indies (5). The senior author collected it in Santo Domingo. Aversa-Sacca (100) gives an account of it as it occurs in Sao Paulo, Brazil.

Spegazzini (73) describes two species of *Leptosphaeria* on cane as new, but neither fits the description of the present species although one is called *L. sacchari* Speg. Neither produced definite spots, nor was more than a dweller on dead leaves or stalks.

A smaller leaf spot very closely resembling that just described occurs to a limited extent but has not been found in fruiting condition. It may in fact be only an abnormal type of the *Leptosphaeria* spot. What is apparently the same thing has been mentioned in Cuban publications (39). (Pl. XXV, fig. 12.)

#### LEPTOSPHERIA SACCHARI van Breda de Haan

Hyphae hyaline to dark, hypogenous, arising from oval gray spots, unbranched; conidia dark, 3-5 septate, obtusely angled, central cell larger than apical cells, 20 X 9  $\mu$ . Perithecia minute, 120-150  $\mu$ . diameter, black, formed beneath the stomata, paraphysate; spores 3-septate, center cells larger than apical cells, 20-24 X 5  $\mu$ ., brownish. Producing a leaf spot of cane. Description after Butler.

PORTO RICO.—On living cane leaves, Juncos, July 27, 1915, 2924; Río Piedras, Nov. 1916, 5849, June, 1917, 6552; Cambalache, March 28, 1916, 5089; Quebradillas, Dec., 1916, 5849; Arecibo, Jan. 1917, 6210. Common everywhere. (Pl. XXV, fig. 1; pl. XXXI, figs. 5, 6.)

#### BROWN LEAF SPOT. (*Cercospora longipes*.)

This is one of the rarer leaf spots in Porto Rico and is of interest chiefly because of the fact that, although of no importance here, it is considered in British India as a very serious source of loss. It again serves to illustrate how the various fungi vary in their severity in the different cane regions.

The spots produced by this fungus are quite typical although they may be at times confused with those due to *Helminthosporium*. They are elongate oval in shape, with a definite margin, a deep brown in color, appearing the same on both sides of the leaf, averaging one

centimeter long by four to six millimeters wide. Spots due to *Helminthosporium* are generally larger, more irregular, and more numerous. The spots rarely coalesce as mentioned by Butler, nor does the leaf appear to die prematurely. Spores are produced on the under surface, and are typical. A second conidial (pycnidia) stage described by Butler has not been found in Porto Rico. It has been collected on two varieties only, Otaheite and P. R. 217. Other than from Porto Rico this disease has been reported only from British India by Butler (10).

#### CERCOSPORA LONGIPES Butler.

Elongate spots on both sides of the leaf, often confluent, at first red, drying to a straw color with a brown ring; hyphae collected in gregarious heads, and generally on the under surface of the leaf, flexuous, brown, above geniculate or denticulate, 100–20 X 4  $\mu$ ., conidia obclavate, tapering upward, straight or curved, 4–6 septate, 40–80 X 5  $\mu$ . Description after Butler.

PORTO RICO.—On living cane leaves, Río Piedras, Feb. 10, 1914, 1641, March, 1917, 6315. Not common. (Pl. XXXI, fig. 11, 12.) Original determination by J. A. S.

#### RED STRIPE OF THE LEAF.

This disease is characterized by a reddening of the midrib, which may vary in length from a mere spot to almost the entire length of the blade. The stripes may be continuous or as is a very marked characteristic at times may occur in sections of varying length with apparently normal areas between. In advanced stages the center of the stripes on the upper surface becomes a dull brown and fruiting pustules will be found. (Pl. XXV, fig. 6.)

The injury due to this disease is negligible under Porto Rican conditions, but Edgerton (25) has demonstrated that in Louisiana the red stripe characteristically gives *Colletotrichum falcatum* when cultured, and may be taken as an early symptom of infection of the plant by this fungus. Stevens of Florida corroborated Edgerton's findings. For this reason some studies have been conducted to ascertain the significance of red stripe in Porto Rico.

These have been carried out by isolations from red stripe specimens, by inoculations, and re-isolations. A number of different fungi have been encountered in the course of this work, mostly forms of *Colletotrichum*.

In a series of isolations commenced October 1, 1912, four of nine tubes yielded a form called *Colletotrichum* C and one tube *Colletotrichum* A. Those remaining were discarded because of contamina-

tions. The two fungi obtained remained true to type in cultures. October 22 a second series was commenced from which *Colletotrichum* C was obtained from ten tubes, *Colletotrichum* B from two, and *Melanconium saccharinum* from one. Further cultures were made in December, from which form C only was obtained. No inoculation tests were made at this time.

In 1916-17 further tests were made of the red-stripe disease. In the first series of inoculations<sup>1</sup> using a culture of *Colletotrichum falcatum* isolated from a diseased stalk, typical striping resulted in all cases (ten) and but one of ten checks showed any signs of infection. A second series of twenty-nine inoculations gave the same result, two out of nine checks also showing striping. All inoculations were made with a hypodermic needle. The cane showed some red striping other than the inoculations, explaining the two checks diseased.

A third series of puncture inoculations of the midrib was made using pure cultures of *Melanconium sacchari*, *Thielaviopsis paradoxa*, *Cytospora sacchari*, *Sclerotium Rolfsii*, and *Trichoderma lignorum*. With the exception of the latter all produced red striping, varying somewhat in the shade of red, but otherwise characteristic of the disease. *Sclerotium* stripes were of a decided orange-red color.

A similar series, using *Melanconium*, *Colletotrichum* C, *Colletotrichum falcatum*, *Cercospora vaginæ*, *Cytospora*, *Thielaviopsis*, and *Sclerotium*, gave similar results. There was considerable variation in color, the two *Colletotrichums* giving the typical color. *Melanconium* and *Thielaviopsis* gave doubtful results. It was possible to reisolate a majority of the fungi used.

A further series of laboratory damp-chamber tests, short externally sterilized sections of reddened mid-ribs being used, gave *C. falcatum* four times, *Colletotrichum* C. once, and an ascomycete (undet.) once.

It is apparent from these studies that more than one form is concerned in the red stripe disease, although *Colletotrichum falcatum* and related forms are most abundant. A wide range of fungi when introduced into a wound are capable of producing red stripes. Red striping is common where a leaf has been injured, but is also equally common where there are no signs of injury. Certain forms commonly found in this connection are here tentatively described.

#### COLLETOTRICHUM A.

Typically small hyaline, slightly falcate spores, forming a cottony white growth on potato cylinders, which become somewhat bluish in

<sup>1</sup> Inoculations made by R. C. Rose, assistant pathologist.



the lower part; spore masses inconspicuous, pink; no setae known; spores varying in shape from cylindrical to falcate; in size from 3.4-10.2 mu. or to 25.5 mu. in length, or 5.2 to 22.1; from 1-celled to 3-celled. (Plate XXVIII, fig. 15.)

This variation in septation naturally throws this fungus out of the genus *Colletotrichum* but as its manner of growth and spore formation is typical of *Colletotrichum* it is here considered in this group.

#### COLLETOTRICHUM B.

Mycelial growth in cultures scanty, white, cottony, spore masses conspicuous, pink; spores cylindrical, rounded at both ends, 3.4-5.1 X 13.6-14.4 mu., spore formation typical of the genus, setae not seen. (Pl. XXVIII, fig. 18-20.)

#### COLLETOTRICHUM C.

Found on the cane in the field as well as on cane in damp chambers: profuse cottony white growth in cultures; minute slightly pinkish spore masses arising from tiny black spots on midrib or blade of leaf; setae absent or commonly present, straight or flexuose, averaging 80 mu. long; spores thick, falcate, averaging 6.8 X 17 mu. (Pl. XXVIII, fig. 10-12.)

The above data combined with the fact that red rot has never been found in connection with red striping at any stage of growth renders the latter worthlessness as a means of diagnosis of the former disease in Porto Rico.

#### WITHER TIP.

This disease is, as its name indicates, characterized by a withering of the tip of a green leaf or the margin of the leaf. The affected portion becomes brown and dead, and on it appears one or more fungi. *Hormiactella* is common in such cases. In addition, the form of *Colletotrichum* described above as *Colletotrichum C.*, is common; as well as *Periconia sacchari*, and *Sphaerella sacchari*.

Under ordinary conditions these fungi may be found on almost any withered leaf. In 1913, a case was noted at Naguabo in which D-625 was severely affected by wither tip at about eight months of age, a very unusual circumstance, but other than these fungi nothing could be found to account for the condition. The plants were all well rooted, were not unusually affected by insects, and seemed to be green healthy plants excepting for the tips of the leaves.

Cobb (15) described a similar disease from Hawaii and figured setae and spores which correspond to those of *Hormiactella*, but without suggesting a name.

# FUNGI AND DISEASES OF CANE CUTTINGS.

## THE PINEAPPLE FUNGUS (*Thielaviopsis paradoxa*.)

The injury caused by this fungus is restricted to the cane cuttings. An affected cutting is usually killed either before any shoots are produced or before the new shoots can establish themselves on their own roots. The loss due to this disease varies considerably, depending upon the variety of cane, moisture condition of the soil, and possibly other factors. As will be noted in more detail later not all seed which fail to germinate have been invaded by this fungus, but it is responsible for the death of a large proportion. Out of one lot of dead seed examined, twenty-five per cent showed this disease and of another lot but ten per cent. The loss in some instances, however, must be much higher. Of healthy seed growing under normal conditions a negligible per cent will be attacked. The disease makes great headway whenever conditions for prompt germination are lacking, and becomes especially severe if the seed has been left in piles or sacks for some time after cutting. For this reason all seed that is to be shipped or which it is not possible to plant at once should be treated.

It is difficult to obtain satisfactory data as to the resistance of the various varieties of cane from field observations alone because of the fact that other fungi are so often involved in the death of seed pieces. To overcome this difficulty seed of a considerable number of varieties was obtained and inoculated with *Thielaviopsis*. After these cuttings had been planted a definite time they were dug up and careful measurements of the amount of infection were taken. The results are given in the following table and it will be noted that there is a very decided varietal difference in susceptibility.

Variety	No. seed planted	Total No. joints	No. joints infected	No. seed infected	% Injury
B. 306.....	20	61	9	9	15
Cavengerle.....	14	49	12	8	50
D. 109.....	20	58	17	11	30
Sealy Seedling.....	17	49	21	12	40
D. 625.....	18	62	23	13	40
Quahotte.....	17	52	23	13	40
B. 3289.....	21	46	27	16	45
T. 77.....	18	55	24	17	60
B. 1753.....	18	47	37	15	65
D. 116.....	18	60	39	18	65
B. 109.....	19	59	35	18	65
Cristalina.....	21	72	51	17	70
D. 117.....	18	56	38	17	70
B. 3696.....	19	65	38	17	70
B. 1355.....	16	66	53	16	80
B. 376.....	15	54	40	14	80
B. 4596.....	14	66	48	14	85
B. 3708.....	14	86	31	13	85
B. 1378.....	18	49	48	16	90
B. 1356.....	16	63	60	16	90

*Thielaviopsis* is a much more serious trouble of pineapples than of cane. It is the cause of practically all of the soft rot or shipping rot as well as a base rot of slips, and spotting of the leaves. The loss from the rot is exceedingly heavy, five to ten per cent of a shipment being not uncommon, and cases are known which ran as high as seventy-five per cent. The fungus has been also reported by Fawcett of the Mayagüez Station as causing a "stem-bleeding of coconuts.

Sufficient inoculations have been made to demonstrate that but one form is involved in the attacks on the various hosts.

A number of experiments have been carried out in seed treatment (51). It was found that when the seed was planted under good conditions no perceptible improvement in germination resulted between treated and untreated lots. When disinfectants were applied to infected seed or to good seed planted under poor conditions, there was considerable improvement. As a consequence of these results, which are in accord with those of other workers, treatment is recommended only where the seed can not be planted at once, or where for some reason conditions are not favorable. Bordeaux mixture is the only practical material now in use for this purpose.

*Occurrence in other countries.*—This disease was reported by Gough (36) in 1911 from Trinidad, and by Edgerton (24) from Louisiana as rare. Of Hawaiian conditions Cobb (14) says "according to my observations the pineapple fungus causes the decay of more cane cuttings in Hawaii than any other one cause. The expense of replanting is largely due to the loss of cuttings through this rot." Butler (10) states that in British India he had found it on three occasions only, all being on recently imported seed from Java and Mauritius. It is of considerable importance in Java where it has been studied by Went (95, 96.) The disease also occurs throughout the British West Indies, (18, 64, 70, 71), particularly in Barbados.

*Description.*—The presence of the fungus can be readily noted by the characteristic blackened sooty area running through the center (Pl. XIX, fig. 3,) of the stalk. There is also a very distinct odor of pineapples present, hence the common name of the disease. There has been much confusion in the literature between *Thielaviopsis* and *Melanconium*, the macro and micronidia of the former having been considered as further stages in the life cycle of the rind disease.

THIELAVIOPSIS PARADOXA (De Seynes) J. Hohn.

Sterile hyphae hyaline, or pale fuscous, septate. Fertile hyphae septate, not branched. Macroconidia ovate, fuscous, catenulate, at length separating, thick walled, usually vacuolate, 16–19 X 10–12

mu. Microconidia cylindric, hyaline, thin walled, catenulate, produced within the hyphae and issuing through the ruptured apex, 10-15 X 3.5-5mu. Microconidiophores 100-200 mu., swollen toward the base. Description after Went and Larson.

PORTO RICO.—From cane cuttings, Yabucoa, March, 1911, 4041; Río Piedras, March, 1912, 4566, June, 1915, 2779. Common everywhere. Also occurs on coconut, and pineapples. (Pl. XIX, fig. 3; pl. XXIX, fig. 8-10.)

#### OTHER FUNGI ATTACKING CANE CUTTINGS.

As has been already noted *Thiaviopsis* is not alone responsible for the death of seed or their failure to germinate. A considerable number of other fungi are commonly found in this connection, as would be expected from the position and unprotected condition of a cutting, presenting ideal conditions for fungus growth. All of these will be greatly favored by conditions which make germination slow or difficult, too deep planting in wet soils, and shallow planting in dry porous soils or in times of drouth.

*Melanconium sacchari* is one of the important fungi found in this connection. In its initial stages it is more difficult to discover than *Thielaviopsis*, a fact which presents a serious obstacle to seed selection. In one instance of a quantity of seed which had been sacked for some time and finally discarded, 110 seed were infected with *Melanconium sacchari*, 67 with *M. saccharinum* and 289 were still sound apparently. Two weeks later, of this latter lot, 135 were infected with *M. sacchari*, 91 with *M. saccharinum*, and 8 with *Thielaviopsis*.

In another experiment, conducted primarily for other reasons, the following fungi were encountered on dead seed pieces, not necessarily the primary cause of death but contributing factors: *Melanconium sacchari*, *Schizophyllum commune*, *Sclerotium Rolfsii*, *Trichoderma lignorum*, *Diplodia cacaoicola*, *Monilia sitophila*, and *Thielaviopsis*. The effect of an unexpected period of dry weather was especially noted as a primary cause of death. Seed inoculated with *Colletotrichum falcatum* suffered severely, some varieties losing as high as thirty-five per cent.

#### MINOR FUNGI AND DISEASES.

Of the various fungi here-in-after considered very few can in any sense be considered as causes of disease. Some act as wound parasites or in some instances have been found apparently as true parasites, but all are of relatively minor importance.



It has been found difficult, if not impossible, to draw a line between those of economic importance and the others, so that all forms found are included. Such a procedure will be of value since some of these fungi may at some time assume a parasitic role or they may be those reported as causes of disease in other cane growing regions.

All are grouped in this one division since it would be rather difficult to assign them to the other sections satisfactorily, growing as they do to a large extent on cane trash or débris, including leaves, stalks, roots and cuttings. Descriptions are given where the original has been modified or changed and of such species as are recorded as new.

*ARCYRIA CINEREA* (Bull) Schum.

PORTO RICO.—On dead leaves, Río Piedras, Jan., 1914, 1169, Nov., 1916, 5806. Also common on dead wood. Determination by Dr. W. C. Sturgis. (Pl. XXV, fig 5.)

A gray, stalked form with cylindrical to elliptical heads, resembling the following species except in color.

*ARCYRIA DENUDATA* Fr.

PORTO RICO.—On dead leaves, Río Piedras, Jan., 1914, 1170, 1915, 3379. A delicate, red, stalked form common on dead wood everywhere. Determination by Mrs. F. W. Patterson.

*CRATERIUM AUREUM* (Shüm) Rost.

PORTO RICO.—On cane trash, Mercedita, Jan., 1912, 4167; Río Piedras, Oct., 1915, 3167, Nov., 1916, 5801. Original determination by Dr. Sturgis. A small stalked form globular to ovoid.

*CRATERIUM LEUCOCEPHALUM* (Pers) Rost.

PORTO RICO.—On cane trash, Río Piedras, July, 1916, 5642. Not common. Determination by Dr. Sturgis.

*DICTYDIUM CANCELLATUM* (Batsch) Macbr.

PORTO RICO.—On cane trash, Oct. 1915, Río Piedras, 3172. Rare. Determination by Dr. Sturgis.

*FULIGO SEPTICA* (L) Gmel.

*Fuligo ovata* (Schaeff) Macbr.

PORTO RICO.—On cane trash, Río Piedras, April, 1912, 4314, July, 1912, 4492; Juana Díaz, March, 1915, 2645. (Comm. Wolcott). Common on plant debris of all kinds. Determination by Dr. Sturgis.

LYCOGALA EPIDENDRUM (L) Fr.

PORTO RICO.—On dead cane stalk, Río Piedras, Feb., 1914, 1319. Also collected on dead bamboo sections and dead wood. Globose, ashen-colored, sessile fruiting bodies, resembling small puff-balls, .5–1 cm. diameter. (Pl. XXIII, fig. 5.)

PHYSARUM CINEREUM (Batsch) Pers.

PORTO RICO.—On living leaves, Manatí, Wolcott, Feb., 1915, 2592. Also collected on living leaves of *Phaseolus vulgaris*. *Lactuca Sativa*, and several common weeds. Determination by Dr. Sturgis.

PHYSARUM COMPRESSUM Alb. & Schw.

PORTO RICO.—On dead leaves, Cortada, Jan., 1912, 4166. Rare. Determination by Dr. Sturgis.

PHYSARUM NODULOSUM (Cooke et Balf.) Mass.

PORTO RICO.—On green leaf-sheaths of cane, Río Piedras, Jan., 1914, 1177. Determination by Mr. F. W. Patterson.

STEMONITIS FUSCA Roth.

PORTO RICO.—On cane trash, Río Piedras, Nov., 1915, 4115. Determination by Mrs. F. W. Patterson.

STEMONITIS SPLENDENS Rost.

PORTO RICO.—On cane trash, Río Piedras, Sept., 1912, 4618, Feb., 1915, 2574. Also common on rotten wood. Original determination by Dr. Sturgis.

EUROTIIUM ARGENTINUM Speg.

PORTO RICO.—On dead cane leaves and stalks, Río Piedras, Nov., 1915, 3245. Observed especially on herbarium specimens. It forms very numerous, minute, yellow, globular fruiting bodies. An *Aspergillus* sp. with dull gray heads occurs in connection with the *Eurotium*.

CHROMOCREA GELATINOSA (Tode) Seaver.

PORTO RICO.—On dead and dying leaf-sheaths of sugar cane, Río Piedras, Jan., 1913, 4751, Jan., 1914, 1171, Feb., 1914, 1409, Feb., 1917, 6380. (Pl. XXVII, fig. 8–10.)

This species produces fleshy, bright yellow stromata on the leaf-sheaths, becoming much darker with age.

**Chromocreopsis striispora** Stevenson sp. nov.

Stromata scattered, tubercular, subglobular to flattened, constricted at the base, often substipitate, 1–3 mm. dia., less in height, brick red at first, duller in dried specimens, with the black necks of the perithecia protruding; asci cylindric; spores uniseriate, dark brown, elliptic-ovoid, ends rounded, 1-guttulate, 20–22 X 5–7  $\mu$ ., striate, striations showing best when spores are partially mature.

PORTO RICO.—On dead cane stalk, Gurabo, July, 1915, 2026 (type). Rare. This species is characterized by the shape and striations of the spores. It was first examined by Dr. F. J. Seaver, who suggested the name.

**GIBBERELLA PULICARIS** (Fries) Sacc.

PORTO RICO.—On dead cane, Río Piedras, April, 1911, 4053, Jan., 1912, 4169, Sept., 1912, 4586, Jan., 1914, 1179; Las Monjas, April, 1911, 4048. Also collected on *Panicum barbinode* and *Eriochloa subglabra*. (Pl. XXVII, fig. 14–15; pl. XXIII, fig. 2.)

The minute, ovoid perithecia of this species are superficial, generally seated on a stroma, black to the unaided eye, but blue with transmitted light.

**HYPOCREA RUFA** (Pers) Fries.

PORTO RICO.—On dead cane stalks, Río Piedras, Jan., 1914, 1199, Feb., 1914, 1322, 1345. Also collected on dead wood. (Pl. XXIII, fig. 1; pl. XVII, fig. 1–2.)

The stromata of this species are subhemispheric, irregular at times, 2 mm. to 1 cm. in diameter, brick red, darker with age, and roughened by the necks of the perithecia.

**NECTRIA FLAVOCILIATA** Seaver.

PORTO RICO.—On dead cane stalks, Río Piedras, Jan., 1914, 1213, Feb., 1914, 1333, 1346. Also collected on dead wood. The less common of the Nectrias. Characterized by a covering of sulphur-yellow hairs. (Pl. XXVII, fig. 16–18.)

**NECTRIA LAURENTIANA** Marshal.

With stromata somewhat broad, convex, superficial, 1–2 mm. dia., seated on a hyaline web, delicate and evanescent; parenchyma white; perithecia densely caespitose, globose, 250–350  $\mu$ . diam., strongly rugose to subsquamulose, ferruginous; asci 8-spored, oblong-cylindrical, attenuate-truncate, finally obtuse, sessile, 60–70 X 7–8  $\mu$ ., paraphysate; spores uniseriate, equilateral, 1-septate, constricted at

the septa, 12-13.5 X 4.5-5 mu., at first strongly granulose, epispore rarely subasperulate. Translation of the original.

PORTO RICO.—On dead and dying cane stalks, April, 1911, 4012, 4047, 4067, Jan., 1914, 1644, 1915, 5164, March, 1916, 5102, July, 1916, 5637; Loíza, June, 1916, 5591. Common. Further study will probably prove it distinct from *N. Laurentiana*, an African form. (Pl. XXVII, fig. 21-23.)

This is a very common fungus on canes primarily injured by borer or other causes, producing a white dry rot.

#### VALSARIA SUBTROPICA Speg.

PORTO RICO.—On rotting cane stalks, Río Piedras, Jan. 1914, 1175. Determination by Mrs. F. W. Patterson. The perithecia are erumpent, scattered or aggregate, black, subglobose, carbonaceous, ostiolate. (Pl. XXI, fig. 3; pl. XXVII, fig. 24-26.)

#### PHYSALOSPORA TUCAMANENSIS Speg.

PORTO RICO.—On dead cane stalk, Carolina, Jan., 1915, 2520. Rare. Determined by Dr. Seaver. This fungus was originally described from Argentina by Spegazzinia (73) on cane leaves, particularly the sheaths. The perithecia are minute, black and emersed in the substratum.

#### ROSELLINIA PARAGUAYENSIS Stark.

PORTO RICO.—On rotting cane stalk, Río Piedras, Jan., 1914, 1179. Determination by Mrs. F. W. Patterson. (Pl. XXXI, fig. 16-18.) The black gregarious perithecia are immersed, then erumpent, and are clothed with a black tomentose subicle.

#### ROSELLINIA PULVERACEA (Ehrh) Fuch.

PORTO RICO.—On dead cane stalk. Río Piedras, Dec., 1916. 5853. Determination by Dr. F. J. Seaver.

The perithecia are crowded, often aggregate crust-like, superficial, globular, very minutely tuberculate, smooth, ostiolate.

#### SPHAERELLA SACCHARI Speg.

Spots none, or indeterminate; perithecia hypophyllous, densely crowded in series, globose, 130-180 mu., smooth, immersed, ostiole scarcely perforating the epidermis, not exserted, membranous coriaceous, subopaque, dark olive. Asci cylindric, 70 X 12 mu., upper end obtuse, lower end, slightly attenuate, abruptly and minutely nodu-

lose-pedicellate, aparaphysate; spores ellipsoid, 16-20 X 5-6  $\mu$ ., 1-septate, scarcely constricted, hyaline, smooth. Description after Spegazzinia.

PORTO RICO.—Common on dead cane leaves, often in connection with *Periconia sacchari*, as the apparent cause of wither-tip or dying of leaves, Fajardo, Dec., 1914, 2536. Commonly observed in all parts of the Island. First described by Spegazzinia (73.)

#### XYLARIA APICULATA Cooke.

Clubs black, stipitate, simple, .5-1 cm. long, apiculate, rarely obtuse; surface with fine raised lines; stipe black, filiform, about 1 mm. thick, smooth, varying much as to length, .5 to 4 cm.; perithecia prominent, papillate; asci cylindrical; spores uniseriate, mostly 6 X 12-14, rarely up to 24  $\mu$ . long, when young with a large gutta, when old with an indistinct septum. Description after Lloyd, Myc. Notes 48: 675.

PORTO RICO.—On dead cane stalks, Río Piedras, Dec., 1913, 1109, Oct., 1915, 3216, July 1917, 6603. Very common on dead wood everywhere.

#### LACHNEA CUBENSIS (B&C) Sacc.

PORTO RICO.—On dead cane leaves, Río Piedras, 1914, 1288. Determination by Dr. F. J. Seaver.

The cups are small, concave, and red with brown marginal setae.

#### GUEPINIA PALMICEPS Berk.

PORTO RICO.—On dead cane stalk, Río Piedras, Feb., 1912, 4288. Determination by Dr. Burt.

Differs from *G. spathulata* macroscopically in the yellow-red tips.

#### GUEPINIA SPATHULATA Jung.

PORTO RICO.—On dead cane stalks, Río Piedras, Feb., 1914, 1330. Common everywhere on rotten wood. Determination by Prof. Lloyd. Producing cartilaginous spatulate, erect, yellow hymenophores, 1-3 cm. tall.

#### ASTEROSTROMA CERVICOLOR (B & C) Mass.

#### *Asterostroma albido-carneum* (Schwein) Mass.

PORTO RICO.—On dead leaf-sheaths at base of living cane stalks, and on soil and cane trash surrounding them, Río Piedras, Dec., 1911, 4109, Sept., 1912, 4632, June, 1917, 6557. Determination by Dr. Burt. (Pl. XXVI, fig. 4-7.)



Forming a thin white layer over the substratum, microscopically characterized by 3-4 armed stellate appendages on the hyphae.

*PENIOPHORA CINEREA* (Fr.) Cke.

PORTO RICO.—On dead cane stalk, Río Piedras, July, 1916, 5638. Determination by Dr. Burt. A very common form on dead wood, particularly on dead branches of citrus, forming cinereous fruiting patches.

*PENIOPHORA FLAVIDO-ALBA* Cooke.

PORTO RICO.—On dead cane stalks, Río Piedras, Dec., 1916, 6068. Determination by Dr. Burt. Common on dead wood.

*TREMELLODENDRON SIMPLEX* Burt, Ann. Mo. Bot. Garden 2:742.  
1915.

Fructifications about 2 cm. long, 2 mm. thick, scattered, erect or suberect, drying hard, brittle somewhat longitudinally wrinkled and sometimes compressed, black above, olive-ocher with the hymenium towards the base; hymenium amphigenous on the lower half of the fructification, olive-ocher, hyaline under the microscope, with the surface consisting of colorless clavate paraphyses 5  $\mu$ . thick, and with basidia and spores at base of the paraphyses; basidia longitudinally septate; 11 X 7  $\mu$ .; spores hyaline, even 7.5-9 X 5-6  $\mu$ . Description after Dr. Burt.

PORTO RICO.—On cane trash, Río Piedras, 1911. Rare.

*HYDNUM SACCHARI* (?) Spreng.

PORTO RICO.—On dead cane, Río Piedras, Jan., 1914, 1174. Determination by Mrs. F. W. Patterson.

*ODONTIA SACCHARI* Burt Ann. Mo. Bot. Garden 4, No. 3. 1917.

Fructification resupinate, effused, portions may be peeled from substratum when moistened, floccose, white, becoming ivory-yellow to pale olive buff with age or in the herbarium, not cracked, the margin thinning out, floccose-reticulate under a lens; granules minute, crowded, about 8 to a  $\mu$ .: in structure 100-300  $\mu$ . thick with the granules extending 15-45  $\mu$ . more, composed of suberect, branched, loosely interwoven hyaline hyphae 3.5-4  $\mu$ . in diam., occasionally nodose-septate, not incrustated, bearing singly along their sides in their middle region hyaline, cylindric, even spores 9-11 X 3-4  $\mu$ .; basidia simple, 2 sterigmata; basidiospores hyaline, even, subglobose, 3.75 X 3-3.75  $\mu$ .; cystidia septate, cylindric, more or less granular incrustated, hyaline, 6-9  $\mu$ . in diam., protruding 20-60  $\mu$ ., about 1-3 to a granule at the apex. Description Dr. Burt's.

PORTO RICO.—On dead leaf-sheaths at the base of living cane stalks and on dead cane stalks, Río Piedras, July, 1912, 4509, July, 1915, 2908, July, 1916, 5628, April, 1917, 6382. Determination by Dr. Burt. Pl. XXVI, fig. 11, 12.)

This same form has been referred to by Horne in Cuba as *Peniophora* sp. and later as probably *Hypochnus sacchari* Speg. (38,39). The latter has also been suggested as the proper designation for the Porto Rican fungus, but Spegazzinia's (73) description of the *Hypochnus* as the cause of a disease of the bud (*cogollo*) of the stalk rather effectively disposes of this possibility to say nothing of the characteristics of the fungus itself. This form is quite clearly a saprophyte only, although at times occurring as does *O. saccharicola*, the more common species, at the base of living cane stalks.

MERULIUS BYSSOIDEUS Burt sp. nov.<sup>1</sup>

PORTO RICO.—On dead cane and soil, Río Piedras, Aug., 1912, 4664. Forming a thin layer on rotten cane trash and soil.

POLYPORUS OCCIDENTALIS Klotzsch.

*Coriopsis occidentalis* (Klotzsch) Murrill.

PORTO RICO.—On dead cane stalk, Río Piedras, Dec., 1913, 1212. Very common on dead wood every-where. (Pl. XXI, fig. 2.)

POLYSTICTUS SANGUINEUS L.

*Pycnoporus sanguineus* (L.) Murrill.

PORTO RICO.—On dead cane stalks, Río Piedras, Jan., 1914, 1181, Feb., 1914, 1294. Very common everywhere, particularly on dead wood. A striking form because of the bright red color of the pileus.

POLYSTICTUS SINUOSUS (Fr.) Sacc.

Color from white to yellowish, mostly resupinate; pores broad, flexuous daedaloid; spores hyaline, cylindric-curved, 5-6 X 1-1.3  $\mu$ .; basidia clavate 15-16 X 4-5  $\mu$ .; hyphae of context tubular. 2.5-3.5  $\mu$ . diam. Description after Saccardo.

PORTO RICO.—On dead cane stalks, Río Piedras, Feb., 1914, 1291, Feb., 1917, 6206; Juncos, July, 1915, 2905. Determination by C. G. Lloyd, Myc. Notes No. 45. (Pl. XXII, fig. 3.)

<sup>1</sup>To be described by Dr. Burt in Ann. Mo. Bot. Garden IV, No. 4, Nov. 1917.

TRAMETES NIVOSA (Berk) Murrill.

PORTO RICO.—On dead cane stalks, Río Piedras, Dec., 1913, 1211, Oct., 1914, 2277, Dec., 1914, 2672, Dec., 1916, 5859. Determination by Prof. Lloyd. A common white form, sporophores often sessile and somewhat abnormally shaped.

LENTINUS CRINITUS (L) Fr.

PORTO RICO.—On dead cane stalks, Río Piedras, Feb., 1914, 1295, Jan., 1914, 1198, Feb., 1916, 6113. Common everywhere on dead wood. Sporophores 4-7 cm. broad, pale-fawn colored to dark reddish brown, covered with stiff squamose hairs.

*Marasmius borinquensis* Stevenson sp. nov.

Pileus minute, delicate, single or gregarious, hemispheric, later expanding, subumbilicate, reaching 3 mm. broad, but commonly 1-2 mm. only; surface radiate-sulcate, glabrous, white, yellow on drying, membranous, margin involute, concolorous; lamellae few, usually about 10, occasionally forked, distant, white, yellow on drying, adnate; spores broad elliptic or ovoid with a small point at one end, 5.1 X 6.8  $\mu$ , hyaline; stipe filiform, concolorous with pileus, slightly villous at base, 2-6 mm. long. Near *Marasmius Marbleae* Murrill.

PORTO RICO.—On cane (Otaheite) Río Piedras, Sept. 10, 1912, 4604 (type) Rare. (Pl. XXVI, fig. 15-17.)

MARASMIUS HIORAMI Murrill.

PORTO RICO.—On cane leaf-sheaths, cane trash, Río Piedras, Sept., 20, 1912, 4600. Rare.

MARASMIUS SYNODICUS (Kze) Fries.

PORTO RICO.—On dead cane trash, Río Piedras, Jan., 1917, 6195. Also collected on dead leaves and stalks of other grasses. Common.

The sporophores of this species are gregarious, 6-10 mm. broad, white or pallid, and 1-2 cm. high, with adnate gills.

SCHIZOPHYLLUM COMMUNE Fries.

PORTO RICO.—On dead and dying cane stalks, Río Piedras, Feb., March, 1911, 4029, 4051, 4058, 4065; Plazuela, July, 1911, 4071. Commonly observed in all parts of the Island. Also very common on dead wood. (Pl. XXII, fig. 4.)

This is one of the commonest forms observed on dead and dying

cane stalks. In one case it was found on a stalk which was otherwise normal, and in many instances it has been noted acting as a wound parasite. It is quite usual to consider it as a cause of a dry rot of cane stalks. It has been reported in this connection from both Java and Brazil (100.)

SCYTINOTUS DISTANTIFOLIUS Murrill.

PORTO RICO.—On dead leaves, Río Piedras, Jan., 1914, 1197. On dead leaves of *Paspalum* sp., Río Piedras, June, 1917. 6494. Determination by J. A. S.

A delicate, white, sessile form, 5–10 mm. broad.

LYCOPERDON ALBIDUM Cooke.

Sessile, globose, white, 8–12 mm. diam.; spores smooth, clay-colored, globose, 3  $\mu$ . diameter.

PORTO RICO.—On cane trash, Río Piedras, Oct., 1915, 3171; Cortada, Jan., 1912, 4168. Determined by Prof. Lloyd. These are the first collections other than the type.

LYCOPERDON PUSILLUM Fr.

PORTO RICO.—On cane trash, Río Piedras, Feb., 1915, 2576. Determined by Prof. Lloyd. Not common.

LYCOPERDON PYRIFORME Schaeff.

PORTO RICO.—In cane fields, Río Piedras, Jan., 1912, 4187, Apr., 1912, 4324; Plazuela, July, 1911, 4075. Very common.

CYATHUS POEPPIGII Tulasne.

PORTO RICO.—On dead cane stalks, Río Piedras, Nov., 1911, 4082. Common on dead wood. First determined by Prof. Lloyd. (Pl. XXIII, fig. 6.)

SPHAEROBOLUS STELLATUS Tod.

Outer peridium stellate-lacinate, lobes 5–8, averaging 1.5 mm. diam.; inner peridium covered by an orange-colored gelatinous envelope which at maturity swells and causes the single sporangiole to be forcibly ejected, spores hyaline, cylindrical-ovate 5.1 X 10.2  $\mu$ . Description modified.

PORTO RICO.—On rotten cane trash, Río Piedras, Jan., 1913, 4750. Also collected on rotten bamboo, leaf-mold, etc. (Pl. XXIII, fig. 4; pl. XXVI, fig. 1–3.)

### PHYLLOSTICTA SACCHARI Speg.

Spots very numerous, with a tendency to occur near the midrib, often confluent, especially at the ends, long linear, occasionally oval, running out into long points, .5-2 cm. X 1-2 mm. at times much larger, red brown at first, then dull tan or brown at center with red, definite, not raised margin; pycnidia hypophyllous on older spots, few to many, uniformly scattered, immersed, membranous, sub-globular, 125-175 mu. diam., prominent ostiole, conidia hyaline to smoky, ovoid to cylindric, ends rounded, 12-16 mu. X 2.5-4 mu., one or two guttulate. Description from specimens.

PORTO RICO.—On living cane leaves, Juncos, July, 1915, 2924; Río Piedras, March, 1917, 6278. (Pl. XXIV, fig. 4.)

In common with some of the other leaf spots, this form has not been worked out satisfactorily. It is probably not *P. sacchari* of Spegazzinia (73) but it has not been thought worth while to name it anew. If it should appear in some abundance hereafter warranting further studies, an attempt will be made to place it exactly. Our specimens differ from one determined by Miss Young from the Stevens' collection as *P. sacchari*. The fragment of this material seen was apparently *Leptosphaeria sacchari*.

### VERMICULARIA GRAMINICOLA West.

PORTO RICO.—On dead cane stalk, Río Piedras, Feb., 1914, 1270. (Pl. XXVIII, fig. 6-8.)

This species is characterized by erumpent, spherical pycnidia, with long black erect setae. It differs very decidedly from *V. sacchari*, described recently by Avena-Sacca, (100) in that the latter possesses biciliate spores, and those of the present species are muticate.

### DIPLODIA CACAOICOLA P. Henn.

Pycnidia scattered in the cortex of the host, innate, black; conidia ellipsoid oblong or sub-ovoid, 1-septate, obtuse at both ends, loculi 1-guttulate, black, 18-22 X 12-14 mu.

PORTO RICO.—On dead cane stalks, Río Piedras, Jan., 1912, 4169, Feb., 1914, 1321, 1347, Oct., 1914, 2278, Oct., 1915, 3169, March, 1917, 6308; Vieques, Jan., 1917, 6194. Fairly common everywhere. (Pl. XXI, fig. 1; pl. XXXI, fig. 8-10.)

This fungus is most commonly found on dead seed pieces or rotten stalks, where the fruiting bodies appear as tiny black bodies buried in the tissues. In some instances, however, it is apparently able to act as a partial parasite, and to cause some loss. This action has



been observed in isolated canes, (generally insect injured stalks), of a number of varieties.

In the case of one variety only, D-625, has it been noted acting apparently alone. Other surrounding varieties in this instance remained normal, but of the D-625 fully twenty-five per cent of the stalks were attacked. The only external symptom was the withering and dying of attacked stalks from the top downward, in no way different from the death of a stalk from any one of many other causes.

Internally was found a very striking rot, which at once distinguished the disease from any other. The rotted areas extended from the top downward, rapidly covering the entire length of the stalk, and attacking the bundles first, which became red in color. The red coloration soon became uniform throughout the central pith region, bordered by an outer periphery of normal tissues. The attacked tissues were somewhat rubbery in consistency, lacking in juice, and rapidly turned brown on exposure to air. The rot finally worked through to the surface producing irregular brown patches on the internodes which finally coalesced. Canes after three months in the laboratory have not yet produced fruiting bodies. *Melanconium sacchari* was occasionally present as a secondary organism. The color of the rot was much deeper than that produced by *Colletotrichum*, the areas were more uniform, and the white patches characteristic of red rot were lacking. *Diplodia* was obtained in cultures.

This fungus, originally described from twigs of cacao, has been reported on cane by Butler (10) in British India and by Howard (41) in Barbados. The former described it as usually saprophytic only, but the latter found it at times parasitic and was able by inoculations to reproduce the disease said to be caused by it. Avena-Sacca (100) gives an account of a disease ascribed to *Lasiodiplodia theobromae*, which is doubtless the same species.

It is extremely doubtful if it will ever be of any real economic importance in Porto Rico, since it attacks only injured canes or weak varieties, D-625 being notoriously of such a nature.

#### MELANCONIUM SACCHARINUM(?) Penz. et Sacc.

Acervuli hypophyllous, gregarious, longitudinally seriate, oblong, 1 mm. long. by .5 wide, black, hysteroid erumpent; conidia large, globose compressed, 24 X 14 mu. black, smooth, borne on filiform, hyaline pedicels. Description after Saccardo.

PORTO RICO.—On cane leaves, Río Piedras, Dec., 1911, 4111, 4112, 4142, 4143, 4144, 4145, 4146, March 1912, 4294, June, 1917, 6559; Mercedita, Jan., 1912, 4171; Fajardo, March, 1912, 4291. On *Cym-*

*bopogon citratus*, Río Piedras, Oct., 1914, 2281. On *Bambusa vulgaris*, Trujillo Alto, Nov., 1914, 2396. Very common in all sections. First determination by Mrs. F. W. Patterson. (Pl. XXIV, fig. 2; pl. XXVIII, fig. 5.)

This fungus is extremely common on many varieties of cane, occurring on the back of the leaf-blades and sheaths and particularly on the back of the mid-rib. It also occurs on the flower stalk. It does very little harm beyond hastening the death of leaves already weakened by other causes. The fungus is conspicuous because of the long lines of black immersed sporodochia opening by long slits, the black spore masses often being visible with a hand lens. Macroscopically it can not be distinguished from *Marsonia* sp.

#### ARTHROBOTRYS SUPERBA Cda.

PORTO RICO.—On dead and dying cane, Río Piedras, July, 1912, 4493. July 1917, 6607. First determination by Mrs. F. W. Patterson. (Pl. XXX, fig. 7–9.)

#### ASPERGILLUS FLAVUS Link.

PORTO RICO.—A very common saprophytic form on dead cane, particularly on seed pieces in the ground, and on material after it is brought to the laboratory. A form morphologically not distinct attacks the mealy bug (*Pseudococcus sacchari*) of cane, often over wide areas. Also isolated from soil, moldy tobacco, and other sources.

#### ASPERGILLUS NIGER Van Tieghem.

PORTO RICO.—A common saprophytic form, particularly noted on imperfectly sterilized material in damp chambers. It produces a reddening of cane tissue.

#### MONILLA SITOPHILA (Mont) Sacc.

Effuse, beautiful deep rose in color, primary hyphae ascending from the procumbent mycelium, 120–130 X 12 mu., scantily septate-constricted, above divided into dichotomous branches; branches and branchlets somewhat broad, crowded, septate and easily separating; conidia aegerogenous, shortly catenulate, globose, 10–12 mu., bases distinctly apiculate where joined by isthmi. Description after Saccardo.

PORTO RICO.—On burnt cane, Río Piedras, March, 1911, 4042, 4057. Also observed at base of *Gynnerium sagittatum* and *Sabal causiarum* where injured by fire. (Pl. XX, fig. 2.)

This very interesting fungus occurs on all debris remaining after

a cane field has been burned over, the very striking orange-pink clumps thickly clustered on every available bit of material over acres and acres make a most striking sight. Where the trash is not burned it very rarely occurs, and never more than as small scattered sporodochia at best. The fungus also causes a mold of bread much more serious than that due to *Aspergillus* or *Mucor*. In the laboratory it evinced a great ability to grow into other cultures and culture media through the cotton plugs and after one experience, during which considerable difficulty was had in getting rid of it, it has never been brought into the laboratory again.

#### TRICHODERMA LIGNORUM (Tode) Harz.

Forming more or less cottony, finally powdery sporodochia, sub-circular to indefinite, up to 5 mm. diameter, white at first, then deep green with white margin; hyphae interwoven, subcompact, filiform, continuous, fertile hyphae erect, 2-4 lageniform branches or conidial bearing organs; conidia formed in globules of 8-10, spherical to elliptical, light green,  $1.4-3 \times 3-4.3$   $\mu$ ; heads averaging 7  $\mu$ . Description amended, after Saccardo.

PORTO RICO.—On dead and dying cane stalks and leaves, Aug., 1912, 4548, 4667, 4666, Jan., 1914, 1173, Jan., 1914, 1201, Oct., 1914, 2275, July, 1915, 2831, Sept., 1915, 3073, Apr., 1917, 6402, June, 1917, 6561. Very commonly observed in all parts of the Island. First determination by Mrs. F. W. Patterson. (Pl. XXI, fig. 4; pl. XXX, fig. 6, 10-12.)

This is an exceedingly common form in and about cane fields and has appeared a great number of times in damp chamber tests and in cultures. It is especially to be found on the lower leaf-sheaths, in connection with *Cerospora*, *Sclerotium*, and other fungi, at times apparently acting as a wound parasite aiding in the death of the leaf-sheaths. Because of the great frequency of its occurrence in the course of laboratory studies on the cane cankers of the mottling disease, internal rots of various types, etc., attempts were made to prove its parasitism, if any, by inoculations. Negative results were obtained, it not even being capable of producing red striping, hence it is now considered only as a saprophyte.

#### *Arthrinium saccharicola* Stevenson sp. nov.

Forming small black masses on the substratum, 1-1.5 mm. diam., not coalescing; sterile hyphae scanty, recumbent; fertile-hyphae simple, suberect to erect; aggregate, hyaline, with broad, black, numerous septae, swollen at base, about 100  $\mu$ . long; conidia sessile,

in a dense spiral about the sporophore, concave-convex when young, becoming doubly-convex, dark brown, 7.25 mu. diam. X 4.4 mu. thick.

PORTO RICO.—On dead cane leaves, Río Piedras, Feb., 1914, 1269 (type). (Pl. XXIX, fig. 1-3.)

#### BASISPORUM GALLARUM Moll.

PORTO RICO.—On dead cane stalks and leaves, Río Piedras, Aug., 1912, 4545; Juncos, Aug., 1915, 2930. Determination by Miss Charles.

Observed on material from all parts of the Island. This is one of the very common saprophytic forms encountered in the work with cane fungi, it being found on all parts of dead and dying cane plants, often forming black irregular patches especially on leaves and dead seed pieces. It has turned up in cultures several times, in one instance of a top-rot case, and of various leaf-spots, but inoculations with it have not been successful. It also occurs on other grasses (*Panicum barbinode*, *Eriochloa subglabra*).

It is characterized by comparatively large black circular or disk-shaped spores, borne on jar-like basidia. The hyphae are hyaline to brown and scanty, and all that is commonly seen are great masses of the conidia.

#### CLADOSPORIUM HERBARUM (Pers) Link.

PORTO RICO.—On cane trash. Río Piedras, Jan., 1917, 6094. April, 1917, 6383. Very common on cane tops and trash lying in the fields after the cane is cut. Appearing as numerous, bright green, slightly raised masses uniformly distributed on the wilted leaves and discarded stalks over all fields, becoming dark green or black. Also common on other host material in many other situations.

#### Hormiactella sacchari Johnston sp. nov.

Sori small, black, scattered, about 1 mm. diam., consisting of sterile erect hyphae mixed with the fertile; sterile hyphae black, septate, more or less straight, 500-900 mu. long; fertile hyphae shorter, 200-300 mu. high, branching sparsely, bearing at intervals short lageniform branches or conidiophores; conidia in short irregular chains, spherical, rugulose, 6 mu. diameter.

PORTO RICO.—On dead cane leaves, Río Piedras, Feb., 1911, 4017, Dec., 1911, 4141, April 1912, 4313, May 1-12, 4353, 4357, August, 1912, 4538, 4567, Oct., 1912, 4638; Mercedita, Jan., 1912, 4153; Yauco, March, 1912, 4315; Canóvanas, July, 1915, 4525, Oct., 1912, 4642; Mameyes, Dec., 1912, 4711; Añasco, May 1916, 5350. Very common everywhere. Often associated with the wither-tip disease of the

leaves. More common on certain varieties. (Pl. XXX, fig. 1-5; pl. XXV, fig. 4)

***Periconia sacchari* Johnston sp. nov.**

Fertile hyphae erect, scattered but very numerous, not blackening the substratum, dark 200-300  $\mu$ . high, with short branches at the tip; branches appressed, cylindrical, or more or less lageniform, sometimes constricted; conidia ovoid or elliptical to finally cylindrical in the mature form, rounded at both ends, brown, finally tuberculate, 11.2 X 22-24  $\mu$ .

PORTO RICO.—On dead and dying cane leaves, often associated with wither-tip, Río Piedras, April, 1917, 6384 (type). Very common. A common associate of *Sphaerella sacchari*. (Plate XXIX, fig. 16-18.)

***Septonema sacchari* Johnston & Stevenson sp. nov.**

Forming small black fruiting patches on the substratum, sterile hyphae recumbent, often not apparent or anastomosing to form a loose net-work; fertile hyphae short but little different from the conidia; conidia catenulate, 1-3 septate, more often 2-septate, basal cell truncate, brown, lighter where the chains branch, minutely spiny, one end cell larger, rounded, and 7.25 X 13-25  $\mu$ .

PORTO RICO.—On cane leaves, Río Piedras, Feb., 1914, 1650, May, 1917, 6404 (type). Macroscopically resembles *Spegazzinia ornata*.

***Tetracoccusporis sacchari* Stevenson sp. nov.**

Forming small, sooty, black, subcircular to irregular masses on the substratum, 1-2 mm. average diam., occasionally coalescing to form masses up to 1 cm. diam.; sterile hyphae recumbent, generally not apparent; fertile hyphae erect, hyaline to smoky, strongly septate; septae appearing as broad black bands at short intervals; spores pleurogenous, sessile, completely covering conidiophore, arranged in regular series, more or less flattened-hemispherical, distinctly rugulose, cruciate-divided into 4 cells, averaging 10  $\mu$ . diam.

PORTO RICO.—On dead cane leaves, Río Piedras, Feb., 1914, 1421, Nov. 1916, 6049 (type). Macroscopically not distinguishable from *Spegazzinia ornata*. (Pl. XXVII, fig. 19, 20.)

**TETRAPLOA ARISTATA (B & Br).**

Plants scattered, few in number, generally among other fungi, olivaceous to black; conidia oblong, biseptate-muriform, brown to sooty, guttulate, 20-30  $\mu$ ., apex formed by four horns, 60-90 X 4  $\mu$ ., pluriseptate, lighter in color than body of spore. Description modified after Saccardo.



PORTO RICO.—On dead cane stalks, Río Piedras, March, 1911, 4010. Very commonly observed when studying other forms, intermixed sparingly with them. (Pl. XXIX, fig. 11.)

*Verticicladium graminicolum* Johnston & Stevenson sp. nov.

Effuse, forming a uniform layer over the substratum, separating readily, dull brown to gray; sterile hyphae interwoven into a fairly compact net work, fertile hyphae erect to reclining, brown, regular, verticillate branched, 3-4 branches at each node; branches cylindrical, short; spores elliptical to cylindrical, hyaline, 3-4 X 6.8-11  $\mu$ .

PORTO RICO.—On cane leaves, Río Piedras, Sept., 1912, 4596. Feb., 1914, 1645 (type). (Pl. XXIX, fig. 14, 15.)

*GRAPHIUM SACCHARI* Speg.

PORTO RICO.—On dead cane stalk, Río Piedras, March, 1911, 4010, Sept., 1912, 4621, Jan., 1914, 1180, Dec., 1916, 5858; Juncos, July 1915, 2925. Quite common. (Pl. XXXI, fig. 13-15.)

*MYROTHECIUM VERRUCARIA* (A&S) Dtm.

PORTO RICO.—On dead and dying cane leaf-sheaths, Río Piedras, April, 1917, 6423. Sporodochia small, flat, dark purple to black with a white, villous margin.

*SPEGAZZINIA ORNATA* Sacc.

PORTO RICO.—On dead cane leaves, Río Piedras, Nov., 1911, 4079, Dec., 1911, 4108, April, 1912, 4311, 4318, July, 1912, 4490, Sept., 1915, 3072, June, 1917, 6551; Ponce, Jan., 1912, 4154; Sta. Isabel, Jan., 1912, 4164. Also collected on dead bamboo, pineapple leaves, and dead leaves of various weed grasses. Very common everywhere. First determination by Mrs. F. W. Patterson. (Pl. XXIX, fig. 6, 7; pl. XXIV, fig. 3.)

The sporodochia are jet black, flat, subhemispherical to irregular, and several mm. in diameter.

*TUBERCULARIA SACCHARICOLA* Speg.

PORTO RICO.—On dead cane stalks, Río Piedras, Aug., 1912, 4667, Jan., 1914, 1214, Feb., 1914, 1340; Carolina, Jan., 1915, 2522; Las Monjas, Apr., 1911, 4049. First determination by Mrs. F. W. Patterson. (Pl. XXIII, fig. 3; pl. XXVII, fig. 5-7.)

# UNDETERMINATE.

*Botrytis* sp.—On dead cane leaves, Río Piedras, 1914, 1422.

*Capnodium* sp.—On living cane leaves and stalks, Río Piedras, 1912, 4507, 4515. Spermatia and *Tripasporium* stages.

*Corticium* sp.—On dead cane leaves, Río Piedras, 1195, 3224. A pink, sterile form.

*Crepidotus* sp.—On rotted cane stalks, Río Piedras, 1203, 1304.

*Dasycephala* sp.—On cane trash, Río Piedras, 2511.

*Fusarium* spp.—A number of species are commonly found on cane trash, material in damp chambers, in cultures of cane soils and in one instance as the apparent cause of a red-rot of cane stalks.

*Lasiosphaeria* sp.—On dead cane, Río Piedras, 1911, 4110.

*Lophodermium* sp.—On dead leaf-sheaths, Río Piedras, 1420.

*Marasmius* spp.—On cane trash a great variety of undeterminable species have been collected.

*Marsonia* sp.—On midribs of dead cane leaves, Río Piedras, 6416, 6429. Macroscopically not distinguishable from *Melanconium saccharinum*.

*Odontia* sp.—On dead cane stalk, Río Piedras, 1916, 6062. Distinct from the other species, but not yet named by Dr. Burt.

*Peniophora* sp.—On cane trash, Río Piedras, 1204. A yellow species, the only collection being sterile. (Pl. XXVI, fig. 13, 14.)

*Polydesmus* sp.—On dead cane leaves, Río Piedras, 1914, 1651. Macroscopically indistinguishable from *Spegazzinia* and *Tetracoccoporis*. (Pl. XXIX, fig. 13.)

*Sclerotium* sp.—On dead and dying cane leaves, particularly the leaf-sheaths, Río Piedras, April 1911, 4044, Aug., 1911, 4077, May, 1912, 4312, Oct., 1912, 4651, May, 1917, 6471. A gray form very distinct from *S. Rolfsii*.

*Stilbum* sp.—On dead cane stalks, Río Piedras, 1343, 1267. Not *S. incarnatum* reported on cane in Java.

*Tapscia* sp.—On dead cane stalks, Río Piedras, 1266. (Pl. XXVII, fig. 3, 4.)

*Trogia* sp.—On dead cane, Río Piedras, 1197. (Pl. XXVI, fig. 18, 19.)

*Valsa* sp.—On dead cane-stalks, Barceloneta, June 1917, 6433. The same species has also been encountered in cultures of leaf spots. It is not parasitic, as far as tests to date show.

*Volutina* sp.—On dead cane, Río Piedras, 1914, 1200. (Pl. XXVII fig. 11-13.)

## DISEASES DUE TO NON-PARASITIC OR DOUBTFUL CAUSES.

### CHLOROSIS.

Chlorosis of sugar-cane has been noted only in the southern and southwestern portions of the Island, the irrigated sections. It is found in varying degree of severity from cases with absolutely white leaves through various shades of yellow to those in which the affected leaves show only yellow stripes. Affected areas vary in size from a fraction of an acre to several hundred acres. It has been especially noted near Ponce, Yauco, and Santa Isabel.

Studies of the phenomenon from a chemical standpoint, have been conducted by Mr. P. C. Gile, (33, 34) of the Mayagüez Experiment Station. He made a soil survey of affected spots, analyses of the soils, and a series of experiments with manure and ferrous sulphate. He ascertained that bleached cane occurred where the soil was excessively calcareous, but that the real cause of the trouble lay in lack of sufficient assimilated iron. Plants treated with a solution of ferrous sulphate either when applied around the roots or painted on the leaves, regained a normal green color.

As a result, however, of the field experiments, the conclusion was reached that while increased yields and a measure of control were secured by applications of iron, the amount necessary made its use on a practical scale, prohibitive.

Field observations show the presence of fungi on chlorotic canes, but to the same extent as on normal cane, so that they have no direct relation with the disease, nor do insects. Earle (21) observed chlorosis near Ponce, confusing it with root disease with which it was associated. Chlorosis of sugar-cane has not been reported from other countries.

### YELLOW STRIPE.

Yellow stripe is more or less of a chlorotic condition in which the chlorosis is restricted to stripes in the leaves. In Porto Rico this has never been seen in more than isolated stools of a field, with the exception of those cases where it occurs in connection with chlorosis on the south side of the Island.

In Java much has been made of this disease, but with no other conclusion than that it was a physiological condition, varying with the different varieties of cane.

### MOTTLING.

About two years ago there was brought to the attention of the junior author a situation in the cane fields of the Arecibo-Aguadilla

district which was at that time already causing considerable loss. Since that time much attention has been given to the disease, several reports have been prepared<sup>1</sup> (75) and extensive field observations and laboratory studies are under way.

Since the initial observations were made the trouble has not only continued its ravages in the original territory, but has greatly enlarged its boundaries so as to include an area extending from near Bayamón to Añasco, or approximately a quarter of the Island. As to how long the disease had been present before the first report was received it has not been possible as yet to ascertain, but certainly a year, so that as near as is now known it has been active about three years. The disease is as yet confined to the upper reaches of the river valleys, to small inland valleys, and particularly to fields among the foot hills. The broad stretches of the coastal plain, but little above sea level, are still free of disease, although they are planted to the susceptible varieties of cane, and form great continuous areas. The rolling stretch of country between Arecibo and Aguadilla, a region which suffers much from drouth has been the most severely infected, and hundreds of acres have been abandoned to cane culture.

*Losses.*—The loss occasioned is very difficult to estimate since the diseased fields will show a variation of from one to a hundred per cent of infection. There appears to be a regular course followed by the disease. A few stools are infected the first year, scattered about the field. The second year infection becomes quite general and there is a decided falling off in yield. The third year the growth of the cane is so poor, and such stalks as are produced are so small, and lacking in juice that the crop is a total loss. The loss is still further increased by the fact that the Centrals refuse to receive any cane that shows evidence of the disease. There is no doubt but that the monetary loss already runs into the hundreds of thousands of dollars.

*Name of the Disease.*—Various names have been used for this disease. It is universally known among the planters as "La enfermedad—the disease," and it has been called "the new disease," the "mottling disease" and "cane canker." The mottling disease is the preferred term. Chlorosis is of course already in use for another trouble.

*Symptoms.*—The one marked and constant symptom of this disease, and the one by which it is easily recognized by any one who has

<sup>1</sup> Stevenson, John A.—La Enfermedad Nueva de la Caña. Circular 11, Insular Experiment Station. 1917.

In La Revista Azucarera, año 2, no. 24, p. 4-5, and no. 25, p. 5-6. 1917.

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Cane Disease in Porto Rico. In La Planter, v. 49, no. 5, p. 76-78. Aug. 4, 1917.

occasion to visit diseased elds, is the peculiar mottling of the leaves. In contrast to the uniform yellowing or whitening of the leaves characteristic of chlorosis, there occur innumerable white or at times yellowish spots and stripes with irregular, indefinite margins. In light cases the back ground may be practically normal green, but more often and especially after the first year the leaves are yellow green to yellow, interspersed with the white markings. It is not apparent that mottled leaves die any sooner, or are more subject to parasitic leaf fungi than normal leaves.

For some time there are no further symptoms than the mottling it being impossible to distinguish, except for this one point, diseased from normal stools. Mottled leaves do not die and fall any sooner than normal ones, nor do they cling abnormally to the stalk. The stalks are not stunted or visibly changed internally. It is quite possible to find stalks which show from one to ten or twelve lower leaves apparently normal, with all those above mottled. The mottling is apparent as soon as the leaves unfold. The reverse condition of normal leaves above, has not been observed. It is not certain yet as to whether a leaf which unfolds normally may become mottled later on. A varying number of stalks in a stool may show mottling, often only one, more often three or four out of a dozen.

The above represents conditions the first year of infection. The ratoon shoots from all infected stools, and from a varying proportion of those that were apparently normal, show mottling from the instant the new shoots are observable. Very seldom does this crop reach normal conditions of height and stand, more often around thirty to fifty per cent only.

At this stage in addition to the mottling another marked characteristic appears, a cankering of the stalks. These cankers or lesions appear first as far as observation show, before the leaf sheaths fall, but after they have become somewhat loosened, as linear spots, somewhat sunken, and brown in color. They soon become ashen or dull gray, and often coalesce to form continuous patches practically covering the internodes. They never, however, pass from one internode to another. They are superficial only, never penetrating for more than 1-2 mm., except along such cracks as occur. Even here the reddening that is found is seldom more than that usually found in such locations in normal cane.

The cracking or splitting is not considered a symptom, being merely a result of the drying up of the cane. Splitting normally occurs in many varieties, although of course it is more marked with this disease. There is no internal red-rot or other form of rot accom-



panying the cankers, but there is a shrinking of the internodes and a general condition of pithiness and lack of juice. All cankered canes show mottling of the leaves, but the reverse is not true.

It may be noted at this point that not only is there a lack of juice in cankered canes, but what does occur is of an objectionable nature from the mill stand point. A very high glucose ratio is reported (non-crystallizing sugars) and the juice behaves badly during clarifying and other processes to which it is subjected. A comprehensive series of chemical tests is about to be made at this Station, to be reported upon later.

*Causes.*—No definite cause has as yet been found although many have been suggested. The juice of diseased stalks has not been found to be infectious. No fungi have been found in connection with it which could reproduce the trouble. It has been found that apparently normal seed pieces from stalks showing mottling, even after disinfection and planting in sterile soil, produced mottled shoots.

The entire question of degeneration or running out of varieties, together with the effect of abnormal weather conditions and exceedingly poor agricultural practices have been studied as far as time and circumstances permitted, and are treated of more fully in other publications on this epidemic.

*Varieties attacked.*—Most of the cane of the infected district has been of two varieties, the striped or *rayada*, and the white (*blanca*) or Otaheite, probably the same as the old Bourbon cane. The white cane was first attacked and is at present most subject to the disease, the cankers being especially characteristic of this variety. Its elimination, as has already occurred in other parts of the Island, seems certain. The *rayada* during the present year has been in many places as badly attacked as the white, although there is still the possibility that strains from outside districts may remain immune.

Other varieties grown on a smaller scale and brought in for trial have been quite uniformly attacked, *bamboo*, *penang*, B-3412, B-208, yellow caledonia, *Cavengerie*, and others. A dark red variety, locally known as *sarangola* has been quite resistant but unfortunately is not a good milling cane, nor is it probable that it would have any great degree of resistance if planted on a large scale.

*Comparison with other cane diseases.*—This disease can not be confused with any of the stalk or leaf diseases described in the earlier part of this paper, the essential symptoms being sufficiently different. Moreover, in no instance has it been possible to find any more evidences of any of these than occur in normal fields. Rind disease has been especially watched for since it is the reputed cause of an

pidemic, that occurred in the British West Indies in 1893-7. It is very easy to find a great variety of fungi but none of them have as yet been capable of reproducing mottling.

The connection of root disease has been a more difficult problem, but it has finally become clear that root disease is not directly connected with the mottling. Either, may and does occur alone, and both are often found acting together, the cane suffering severely in any case.

The more the disease is studied the more it appears to resemble the mysterious "sereh" of Java. It is quite unlikely that it is that exact disease, but it is not improbable that it is of the same general nature, produced by the same or similar environmental factors. Many of the symptoms are the same, although none it must be admitted are those that are considered essential; for instance the course of the disease over three years, the stunting of stools and shortening of internodes (in advance cases), the fact that the disease is carried from old plants to new ones by cuttings, and a poor development of the root system. On the other hand this new disease in addition to the leaf mottling and stalk cankers not ascribed to "sereh," does not show gumming, internal red lines, more disease at the base of the stalk, or the abnormal stooling giving the grassy appearance from which the "sereh" takes its name.

*Control.*—Practically every conceivable measure which has ever been recommended for the control of cane diseases and especially those usually given as efficacious for root disease have been tried, and without any other result than the continued progress of the disease. Liming, increased cultivation, treatment with Bordeaux mixture, seed of established varieties brought from outside regions, seed of new varieties, and the use of land not before planted to cane, all these, and more have been tried.

It is apparent that very drastic measures will be necessary to check the epidemic. The foremost requirement will be the introduction of a rotation system, (a heretofore unknown practice in Porto Rican cane culture), and one which will include a legume. It is no easy matter to give a satisfactory outline for such a rotation, particularly the legume, and even after by such experimentation such is found, it is going to be equally or more difficult to get it adopted. In the meanwhile continued efforts are being made with new seedling varieties, particularly those produced at this Station, and it is hoped that some will ultimately be found which under proper care will succeed.

A complete account of the disease to date together with such

studies as have been made will occur in the forthcoming report of the Experiment Station, (1916-1917).

#### INJURIES DUE TO NATURAL AGENCIES.

In order to round out the subject of cane disease, it has been considered proper to include a consideration of injuries due to such physical phenomena or natural causes, as lightning, wind, drouth, and floods, often important sources of loss to the cane growers of the Island.

##### LIGHTNING.

Lightning injury to sugar-cane is apparently rare, but one instance having been observed (75). In this case all the cane, including the roots, in an area of approximately a square rod was killed, producing an open spot sharply set off from the surrounding normal cane. Nothing was left of the cane but charred remains of leaves and a few short pieces of stalk, some remaining erect. A growth of herbaceous weeds followed. No insects or fungi were present, even a considerable time after the cane was killed.

##### WIND.

Under normal conditions cane is quite resistant to direct injury from wind, although of course there is the indirect effect of the increased evaporation of the soil water supply, and checking of growth or even death when a shortage occurs.

The occasional hurricanes, however, often cause considerable losses depending somewhat upon the season in which they occur, or upon the age of the cane. With extreme wind velocities the cane may be uprooted over large areas, making practically a total loss, or young ratoons may be so wrenched and loosened as to give greatly decreased yields. Over the eastern end of the Island a decided falling off in estimated production was accredited to this cause in the season just ended.

Cane does not, however, suffer from wind to the extent that other crops, coffee and citrus, for example, do.

##### FLOODS, AND EXCESSIVE WATER SUPPLY.

Cane, a shall rooted crop is much subject to damage by floods. During the periodic overflows, characterizing the rivers of Porto Rico, much low land cane is washed out or the hold of the plants so weakened by the washing away of the soil that an effort must be put forth to recover, which must mean decreased yields. Cane is, however, the most resistant crop to this sort of condition.

It is generally considered that an excessive water supply, due to heavy soil or poor drainage, is very harmful. Such a condition is doubtless beneficial to the growth of many injurious fungi and there is a decrease in yield through loss of roots by disease or drowning (suffocation). Observations, made in connection with the mottling disease, have indicated that cane suffers more readily from a lack of water than from an over abundance.

#### DROUTH.

This is undoubtedly the most important of the various factors considered under the general heading. Large sections of the Island are so habitually dry that irrigation is absolutely necessary, and there are other important districts which suffer from periods of drouth of greater or less length at various seasons of the year. The influence of lack of sufficient water has been readily noted in those places where irrigation has been applied to some fields only. It often spells the difference between a crop and no crop.

One very important effect credited to lack of water is increase of root disease. There is undeniably an increase in the amount of fungus present, and it is not uncommon to find whole fields of stunted, yellow cane, apparently ruined by root disease. The exact relation of drouth and the fungi found in connection with the roots and the stalks of the cane is debatable.

It seems altogether probable that the most trying situation for cane is a succession of excessive rains and long drouths, a state of affairs often existing over large sections of Porto Rico.

#### ABNORMALITIES.

In Java the various abnormalities of the cane plant have been considered at great length (53). Many of the types reported for that Island occur in Porto Rico, but in isolated cases so that no significance is attached to them in the pathological work.

Canes are quite commonly found with buds or eyes missing from some of the nodes, or sometimes with two or more eyes at a node. Germination of the eyes in situ often with the production of lengthy shoots is common, being quite characteristic of certain varieties. It also occurs at times in connection with stalk-borer or other injuries.

There have occurred types of growth resembling those described for "sereh," the short grass-like habit for instance, and the production of adventitious roots along the stalk, but without other symptoms being present. Such cases have occurred in connection with root disease or insect injury.

## CANE FUNGI OF SANTO DOMINGO.

Because of the close proximity of Santo Domingo and the fact that cane for milling is brought from there in large quantities by one of the Central companies, there has always been considerable interest taken in the cane fungi of this Island and the possibility of introducing new diseases to Porto Rico through this channel. Because of this threatening danger the senior author visited Santo Domingo some years ago making special search for diseases not already occurring Porto Rico and at the same time collecting all cane fungi found. A report of this trip was published at the time (49) and included mention of some five fungi causing the common diseases noted. Since that time determinations have been made of the other fungi collected and a complete list is here given with the localities in which found. It will be noted that no fungi are contained in the list not already reported as occurring in Porto Rico. All collections were made by Mr. Johnston, between April 4 and 20, 1913.

*Cercospora vaginæ* Krüger.—Common at Higüral and other points.

*Colletotricum falcatum* Went.—San Pedro de Macoris, Santo Domingo City.

*Craterium aureum* (Shüm) Rost.—La Romana.

*Diplodia cacaoicola*. P. Henn.—La Romana, San Pedro de Macoris.

*Graphium sacchari* Speg.—La Romana.

*Helminthosporium sacchari*, Butler.—Higüral. Linear leaf spot.

*Hormiactella sacchari* Johnston.—San Pedro de Macoris.

*Leptosphaeria sacchari*. V. Breda de H.—La Romana. Common in all fields.

*Lycogala epidendrum* (L) Fr.—Higüral.

*Marasmius sacchari* Wakker.—Higüral, Santo Domingo City. As sterile mycelia only.

*Melanconium sacchari* Masee.—San Pedro de Macoris, La Romana. Common on old cane.

*Melanconium saccharinum* Penz. & Sacc.—Higüral.

*Nectria laurentiana* Marchal.—San Pedro de Macoris.

*Odontia saccharicola* Burt.—La Romana.

*Sclerotium* sp. The gray form.—San Pedro de Macoris.

*Schizophyllum commune* Fries.—La Romana.

*Sclerotium* sp. The gray form.—San Pedro de Macoris.

*Tetraploa aristata* B & R.—San Pedro de Macoris.

*Thielaviopsis paradoxa* (De Seynes) V. Hohn.—La Romana, Higüral.



*Trametes nivosa* (Berk) Murrill.—La Romana, Higüral.  
*Tubercularia saccharicola* Speg.—Santo Domingo City.

#### CONTROL OF CANE FUNGI.

It is impracticable, in fact impossible, to entirely eliminate fungi from the cane fields. It is, rather, the aim of the good agriculturist, to produce as vigorous cane as possible and so reduce the fungi to a minimum. There are very few cane diseases that will not yield to proper agricultural methods combined with certain principles of control to be outlined here.

Space will not permit a consideration of the various points included under "proper agricultural methods," such as good drainage, irrigation when necessary, selection of seed, proper planting and cultivating. They are fully covered in other publications of this Station.

Among the control principles may be mentioned the following, a brief exposition of each being given.

1. Healthy seed only should be used for planting, since normal cane can hardly be expected from diseased seed. This means that all seed should undergo a careful selection to eliminate any that show borer or other insect injury, the presence of the mycelium of *Odontia* or other fungi, internal discolorations or rot due to *Melanconium*, *Colletotrichum*, *Diplodia*, or other cane-destroying agent. Seed selection should be carried out in the field where the cane is cut and not where it is to be planted.

2. Certain varieties of cane are more resistant to a given disease or diseases than others. An effort should be made to discover these by comparative tests and to use those that give the best results. The root disease often yields to a change in variety as do other diseases. Care should be exercised not to mix different varieties in the same field.

3. Certain diseases, particularly *Thielaviopsis*, are prevented by disinfection of the seed or by providing a protective covering. Bordeaux mixture is the only practicable substance for this purpose and gives good results where conditions are not favorable for quick germination or where the seed can not be planted at once.

4. Various other plants which harbor cane fungi should not be grown in rotation with cane or in the case of weeds they should be kept down as thoroughly as possible. This will apply especially to pineapples, which are very subject to *Thielaviopsis* and to various grasses attacked by *Odontia*, some of them of economic value. Permitting the land to revert to pasture after the cane is abandoned does not serve to kill out those fungi that attack the cane roots. It will

be far better to rotate cane with some leguminous crop, such as sword beans, cow-peas, or velvet beans.

5. Effort should be made to reduce to a minimum cane injured through attacks by borer, other insects, cattle, rats, or other agencies; such injured canes being readily attacked by various fungi. Gaining a foothold on injured canes, the fungi may spread to adjoining healthy cane.

6. Cane should not be allowed to become overmature, since many diseases are capable of causing severe damage to such cane. This applies particularly to *Meconium* and *Colletotrichum* which often ruin whole fields of certain varieties. It must be noted that some varieties can be left until a second season without cutting, provided they are growing under good conditions, but they must be watched, since the disease, once it gets a foothold spreads very rapidly.

#### SUMMARY.

Fungi have caused heavy loss in the cane fields of Porto Rico. Diseases have been present in serious amounts since at least 1870 and are quite prevalent at the present time, presenting a number of difficult problems. Cane diseases have been studied in Porto Rico by various agronomists and commissions of the Spanish times and since the American occupation to some extent by the Federal Experiment Station. Most of the work in this field has been carried out by pathologists of what is now the Insular Experiment Station.

There are a considerable number of important cane diseases not occurring in Porto Rico, "sereh," gumming, etc.

Of the fungi found chiefly on the roots or base of the stalk are *Marasmius sacchari*, *Himantia stellifera*, and *Odontia sacchari*. These are all concerned to a greater or less extent in the so-called root disease. Studies on their exact relationships and parasitism have not yet been carried out.

The principal diseases of the stalk are red rot (*Colletotrichum falcatum*, rind disease, (*Melanconium sacchari*), and a new disease due to *Cytospora sacchari*, which proved threatening to certain varieties. The two former diseases especially attack overmature or injured cane.

A number of leaf diseases are found, none of which cause appreciable loss although they are of universal occurrence. Those described are red spot of the leaf-sheath (*Cercospora vaginæ*), red rot of the leaf-sheath (*Sclerotium Rolfsii*), eye spot (*Helminthosporium sacchari*), ring spot (*Leptosphaeria sacchari*), brown leaf spot (*Cercospora longipes*), red stripe, and wither-tip.

The only important disease of cane cuttings is that due to *Thielaviopsis paradoxa*, readily prevented by dipping the seed in Bordeaux mixture.

Under the heading of minor fungi and diseases seventy-two fungi are listed, together with notes of occurrence, and the symptoms of any diseases they may cause.

Chlorosis a disease characterized by a yellowing or whitening of the leaves and occurring in certain districts on the south coast, is described together with experiments for its control. Yellow striping is a phenomenon occurring to a very limited extent.

An account is given of the new disease, or mottling of cane, a phenomenon existing in the western end of the Island. It is characterized by a peculiar mottling of the leaves, and later by a cankering of the stalks. All varieties are attacked, and it has occasioned very heavy losses. No certain control measures are known.

Injuries due to natural agencies, lightning, wind, floods, and drouth are discussed.

Certain abnormalities are mentioned, but are of little importance.

A list of the cane fungi of Santo Domingo is appended.

Certain of the principles of control of cane diseases are briefly outlined.

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EXPLANATION OF PLATES.

PLATE XIX.

- Fig. 1.—*Odontia saccharicola* (Slightly reduced.)  
Fig. 2.—*Himantia stellifera*. Mycelium on leaf-sheath. X 1.  
Fig. 3.—*Thielaviopsis paradoxa*. Section of infected cane cutting. X 1.

PLATE XX.

- Fig. 1.—*Marasmius sacchari*. Sporophores X 1.  
Fig. 2.—*Monilia sitophila*. X 1.  
Fig. 3.—*Melanconium sacchari*. Showing pustules on stalk. X 1.  
Fig. 4.—*Colletotricum falcatum*. Black fruiting areas on exposed surface of inoculated seed piece X 1:

PLATE XXI.

- Fig. 1.—*Diplodia cacaoicola*. Erumpent clusters of pycnidia. X 2.  
Fig. 2.—*Polystictus occidentalis*. X 1.  
Fig. 3.—*Valsaria subtropica*. X 2.  
Fig. 4.—*Trichoderma lignorum*. X 2.

PLATE XXII.

- Fig. 1.—*Cytospora sacchari*. Showing beaked pycnidia. X 2.  
Fig. 2.—*Cytospora sacchari*. Cankers produced on cane stalk. Slightly reduced.  
Fig. 3.—*Polystictus sinuosus*. X 1.  
Fig. 4.—*Schizophyllum commune*. X 1.

PLATE XXIII.

- Fig. 1.—*Hypocrea rufa*. X 2.  
Fig. 2.—*Gibberella pulicaris*. X 2.  
Fig. 3.—*Tubercularia saccharicola*. X 2.  
Fig. 4.—*Sphaerobolus stellatus*. X 2.  
Fig. 5.—*Lycogala epidendrum*. X 2.  
Fig. 6.—*Cyathus Poeppigii* X 2.

PLATE XXIV.

- Fig. 1.—*Cercospora vaginae*. X  $\frac{1}{2}$ .  
 Fig. 2.—*Melanconium saccharinum* X 2.  
 Fig. 3.—*Spegazzinia ornata*. X 4.  
 Fig. 4.—*Phyllosticta sacchari*. Slightly reduced.

PLATE XXV.

- Fig. 1.—*Leptosphaeria sacchari*. X 1.  
 Fig. 2.—The "smaller" leaf spot X 1.  
 Fig. 3.—*Sclerotium Rolfsii*. X 2.  
 Fig. 4.—*Hormiactella sacchari*. X 2.  
 Fig. 5.—*Arcyria cinera*. X 2.  
 Fig. 6.—Red stripe of the leaf. X  $\frac{1}{2}$ .

PLATE XXVI.

- Fig. 1, 2.—*Sphaerobolus stellatus*. Gross appearance.  
 Fig. 3.—*Sphaerobolus stellatus*. Spores.  
 Fig. 4.—*Asterostroma cervicolor*. Stellate appendage of mycelium.  
 Fig. 5.—Same, immature condition.  
 Fig. 6, 7.—*Asterostroma cervicolor*. Basidia and spore.  
 Fig. 8, 9.—*Marasmius sacchari*. Gross appearance.  
 Fig. 10.—*Marasmius sacchari*. Spore.  
 Fig. 11.—*Odontia sacchari*. Cystidium.  
 Fig. 12.—*Odontia sacchari*. Basidium with one spore.  
 Fig. 13.—*Peniophora* sp., Basidium and spores.  
 Fig. 14.—*Peniophora* sp., Cystidium.  
 Fig. 15, 17.—*Marasmius borinquensis*. Gross appearance.  
 Fig. 16.—*Marasmius borinquensis*. Spore.  
 Fig. 18.—*Trogia* sp. Gross appearance.  
 Fig. 19.—*Trogia* sp. Spore.

PLATE XXVII.

- Fig. 1.—*Hypocrea rufa*. Diagrammatical section of stroma, showing position of perithecia.  
 Fig. 2.—*Hypocrea rufa*. Ascus and spores.  
 Fig. 3.—*Tapesia* sp. Apothecia in various stages.  
 Fig. 4.—*Tapesia* sp. Ascus and spores.  
 Fig. 5.—*Tubercularia saccharicola*. Diagrammatic vertical section of sporodochia.  
 Fig. 6.—*Tubercularia saccharicola*. Spores.  
 Fig. 7.—*Tubercularia saccharicola*. Conidiophores.

Fig. 8.—*Chromocrea gelatinosa*. Diagrammatic vertical section of stroma.

Fig. 9.—*Chromocrea gelatinosa*. Portion of ascus.

Fig. 10.—*Chromocrea gelatinosa*. Spore.

Fig. 11.—*Volutina* sp. Sporodochium, much enlarged.

Fig. 12.—*Volutina* sp. Conidia.

Fig. 13.—*Volutina* sp. Portion of seta.

Fig. 14.—*Gibberella pulicaris*. Ascus.

Fig. 15.—*Gibberella pulicaris*. Spores.

Fig. 16.—*Nectria flavociliata*. Perithecium.

Fig. 17.—*Nectria flavociliata*. Portion of seta.

Fig. 18.—*Nectria flavociliata*. Ascus and spores.

Fig. 19.—*Tetracoccusporis sacchari*. Fertile hypha.

Fig. 20.—*Tetracoccusporis sacchari*. Conidium.

Fig. 21.—*Nectria laurentiana*. Habit sketch of perithecia.

Fig. 22.—*Nectria laurentiana*. Ascus.

Fig. 23.—*Nectria laurentiana*. Spore.

Fig. 24.—*Valsaria subtropica*. Ascus.

Fig. 25.—*Valsaria subtropica*. Spore.

Fig. 26.—*Valsaria subtropica*. Diagrammatic vertical section, showing perithecia.

#### PLATE XXVIII.

Fig. 1.—*Cytospora sacchari*. Diagrammatic vertical sections of stromata.

Fig. 2.—*Cytospora sacchari*. Conidium.

Fig. 3.—*Cytospora sacchari*. Diagrammatic cross-section of stroma.

Fig. 4.—*Cytospora sacchari*. Conidiophore.

Fig. 5.—*Melanconium saccharinum*. Conidia.

Fig. 6.—*Vermicularia graminicola*. Habit sketch.

Fig. 7.—*Vermicularia graminicola*. Conidium.

Fig. 8.—*Vermicularia graminicola*. Pyrenidium.

Fig. 9.—*Colletotrichum falcatum*. Conidium.

Fig. 10.—*Colletotrichum C.* Conidium.

Fig. 11.—*Colletotrichum C.* Conidia, setae, conidiophores.

Fig. 12.—*Colletotrichum C.* Setae.

Fig. 13.—*Colletotrichum falcatum*. Acervulus.

Fig. 14, 16, 17.—*Colletotrichum falcatum*. Conidia and conidiophores, showing variation in conidia.

Fig. 15.—*Colletotrichum A.* Conidia and conidiophore.

Fig. 18, 19, 20.—*Colletotrichum B.* Conidia and conidiophores.

PLATE XXIX.

- Fig. 1.—*Arthrinium saccharicola*. Fertile hypha.  
 Fig. 2.—*Arthrinium saccharicola*. Base of fertile hypha.  
 Fig. 3.—*Arthrinium saccharicola*. Conidium.  
 Fig. 4.—*Helminthosporium sacchari*. Conidium.  
 Fig. 5.—*Helminthosporium sacchari*. Conidiophores.  
 Fig. 6.—*Spegazzinia ornata*. Conidiophore and conidia.  
 Fig. 7.—*Spegazzinia ornata*. Immature conidia.  
 Fig. 8.—*Thielaviopsis paradoxa*. Microconidia.  
 Fig. 9.—*Thielaviopsis paradoxa*. Macroconidia.  
 Fig. 10.—*Thielaviopsis paradoxa*. Micro-and macro-conidio-  
 phores.  
 Fig. 11.—*Tetraploa aristata*. Conidium.  
 Fig. 13.—*Polydesmus* sp. Conidia.  
 Fig. 14.—*Verticicladium graminicolum*. Conidiophore.  
 Fig. 15.—*Verticicladium graminicolum*. Conidium.  
 Fig. 16.—*Periconia sacchari*. Conidiophore and conidia.  
 Fig. 17.—*Periconia sacchari*. Mode of branching.  
 Fig. 18.—*Periconia sacchari*. Conidium.  
 Fig. 19.—*Cercospora vaginae*. Conidiophores.  
 Fig. 20.—*Cercospora vaginae*. Conidia.

PLATE XXX.

- Fig. 1.—*Hormiactella sacchari*. Portion of conidiophore.  
 Fig. 2.—*Hormiactella sacchari*. Portion of conidiophore and co-  
 nidia.  
 Fig. 3.—*Hormiactella sacchari*. Mode of branching.  
 Fig. 4, 5.—*Hormiactella sacchari*. Habit sketches.  
 Fig. 6.—*Trichoderma lignorum*. Conidiophores.  
 Fig. 7.—*Arthrobotrys superba*. Conidiophore and conidium.  
 Fig. 8.—*Arthrobotrys superba*. Conidium.  
 Fig. 9.—*Arthrobotrys superba*. Portion of fertile hypha.  
 Fig. 10.—*Trichoderma lignorum*. Same as fig. 6. Enlarged.  
 Fig. 11, 12.—*Trichoderma lignorum*. Mode of formation of co-  
 nidia.

PLATE XXXI.

- Fig. 1.—*Himantia stellifera*. Diagrammatic cross-section of cane  
 rootlet, showing at X location of crystal bearing hyphae.  
 Fig. 2.—*Himantia stellifera*. Portion of section shown in Fig.  
 1, enlarged.



- Fig. 3.—*Himantia stellifera*. Hypha and crystal.  
Fig. 4.—*Himantia stellifera*. Swollen tips of hyphae.  
Fig. 5.—*Leptosphaeria sacchari*. Ascus, and paraphysis.  
Fig. 6.—*Leptosphaeria sacchari*. Spores.  
Fig. 7.—*Melanconium sacchari*. Conidium.  
Fig. 8.—*Diplodia cacaoicola*. Habit sketch.  
Fig. 9, 10.—*Diplodia cacaoicola*. Conidia.  
Fig. 11.—*Cercospora longipes*. Conidiophore.  
Fig. 12.—*Cercospora longipes*. Conidium.  
Fig. 13.—*Graphium sacchari*. Synnema.  
Fig. 14.—*Graphium sacchari*. Conidia.  
Fig. 15.—*Graphium sacchari*. Portion of conidiophore.  
Fig. 16.—*Rosellinia paraguayensis*. Asci and paraphyses.  
Fig. 17.—*Rosellinia paraguayensis*. Spore.  
Fig. 18.—*Rosellinia paraguayensis*. Diagrammatic vertical section of stroma.



PLATE XIX.

Sugar-cane Fungi of Porto Rico.

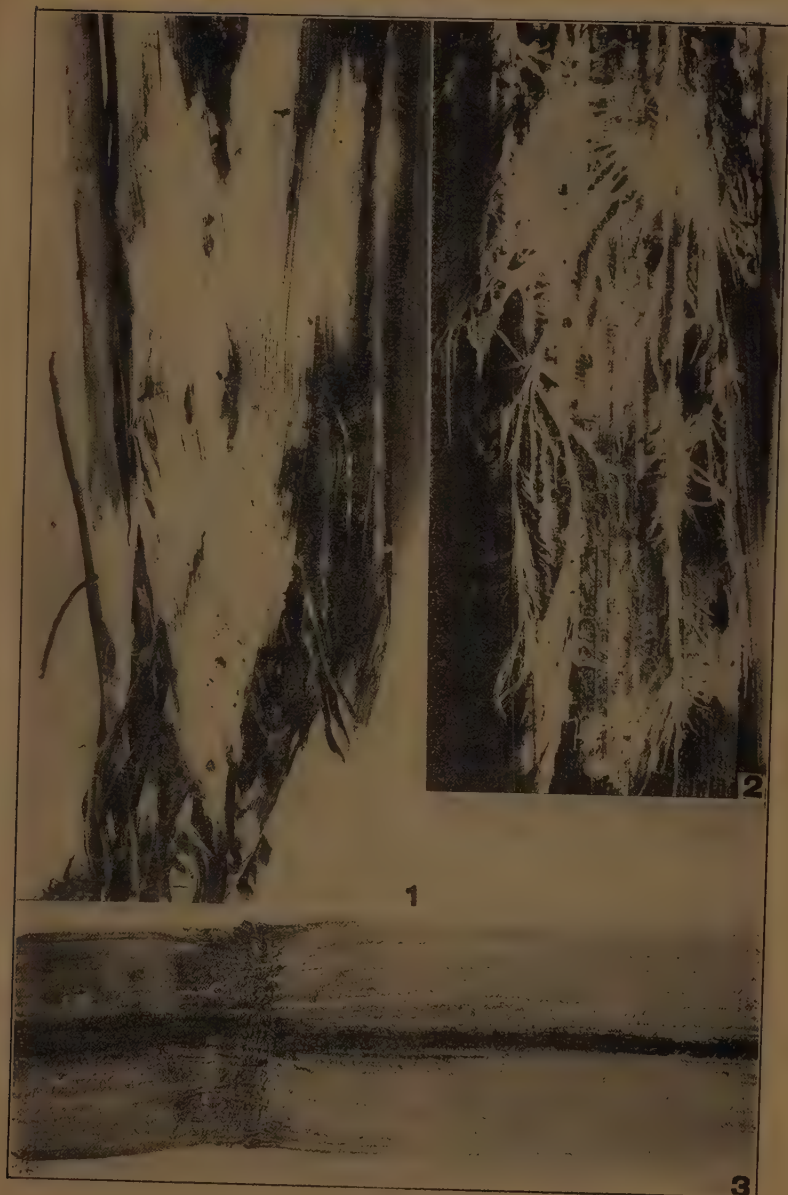




PLATE XX.

Sugar-cane Fungi of Porto Rico.

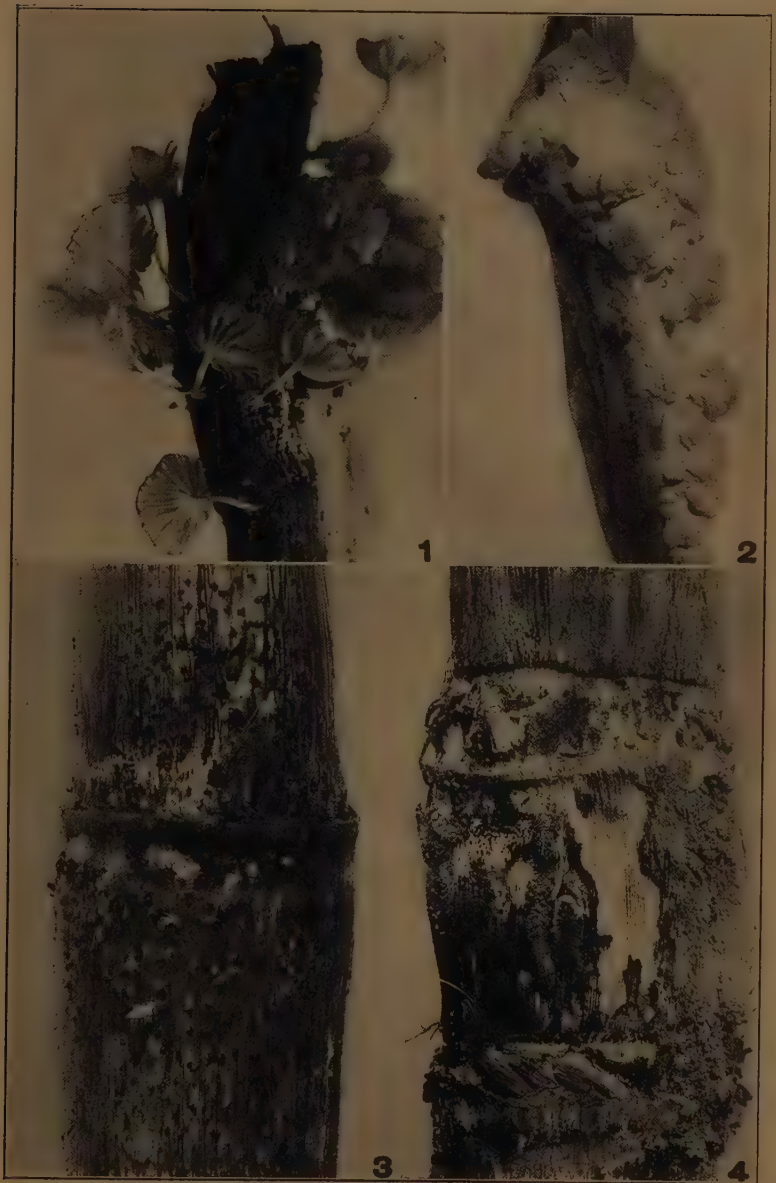






PLATE XXI.

Sugar-cane Fungi of Porto Rico.

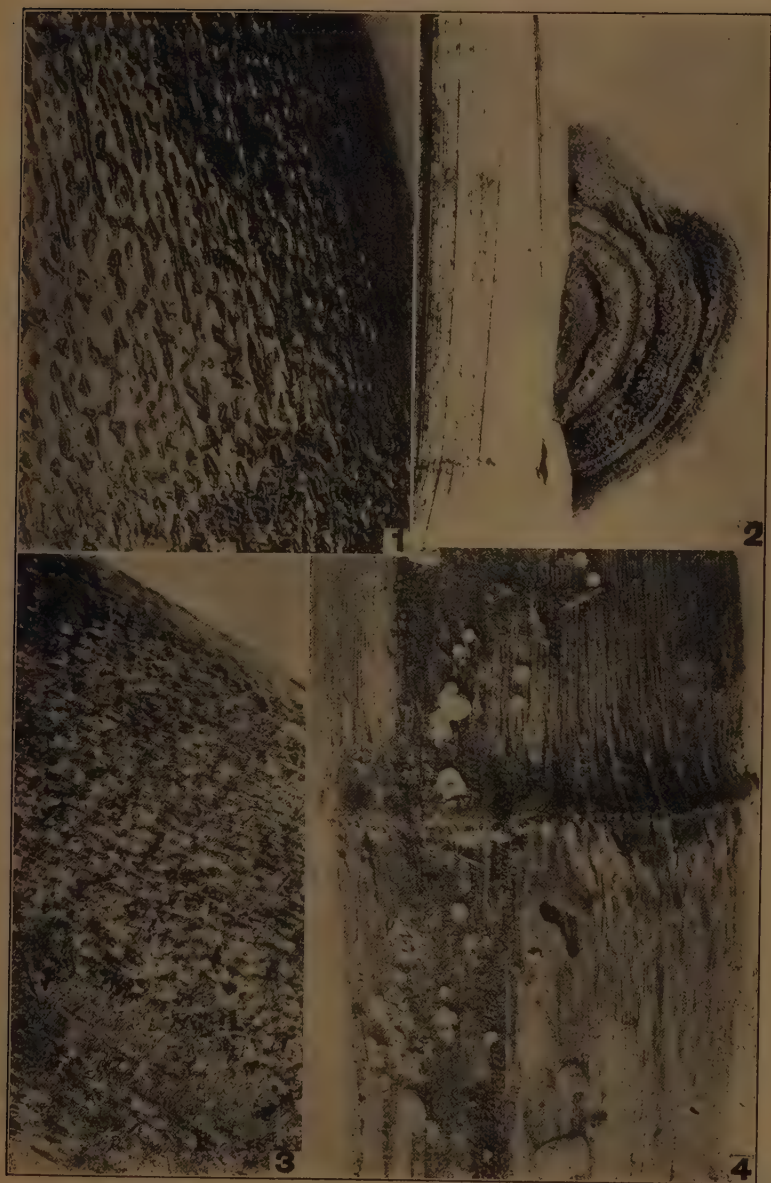




PLATE XXII.

Sugar-cane Fungi of Porto Rico.

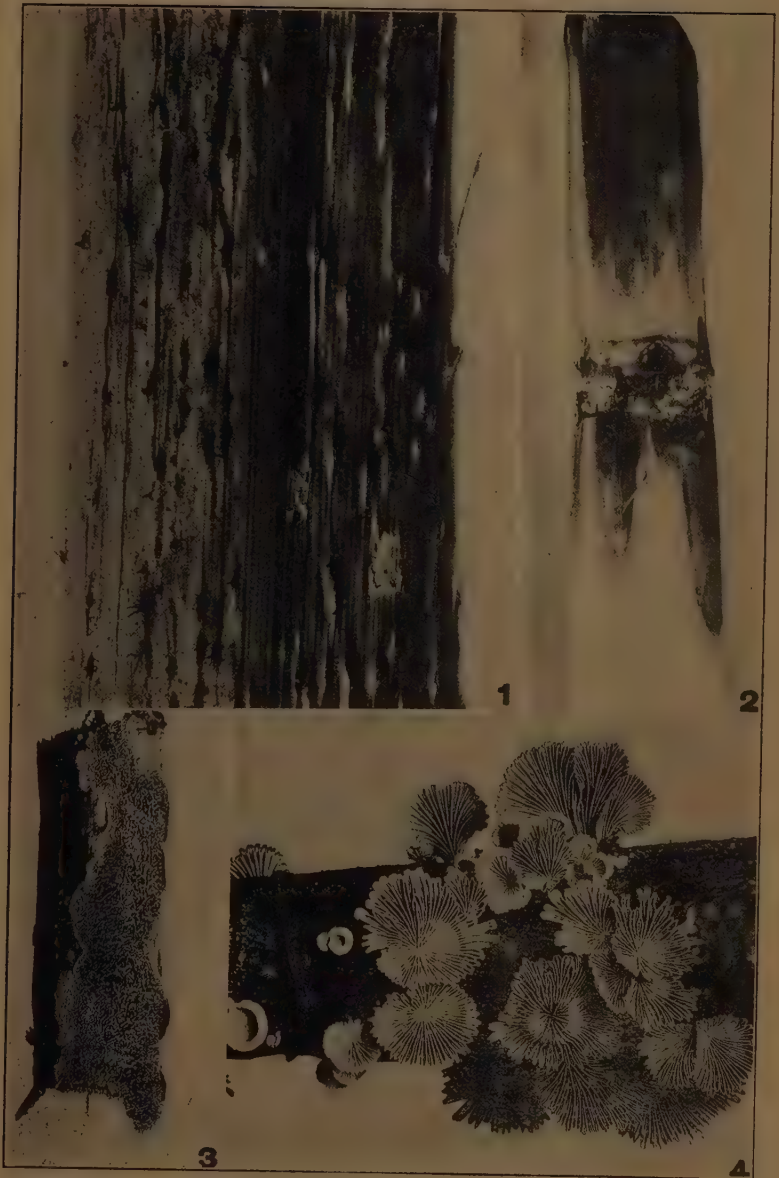
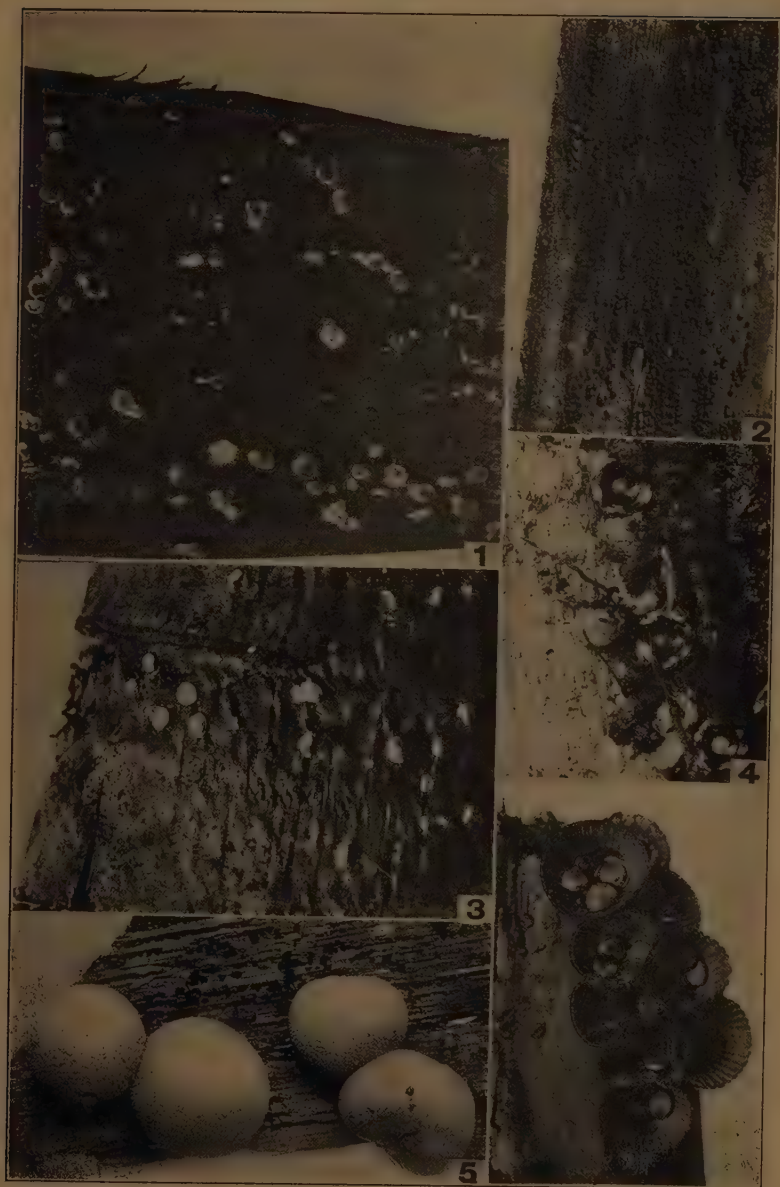






PLATE XXIII.

Sugar-cane Fungi of Porto Rico.



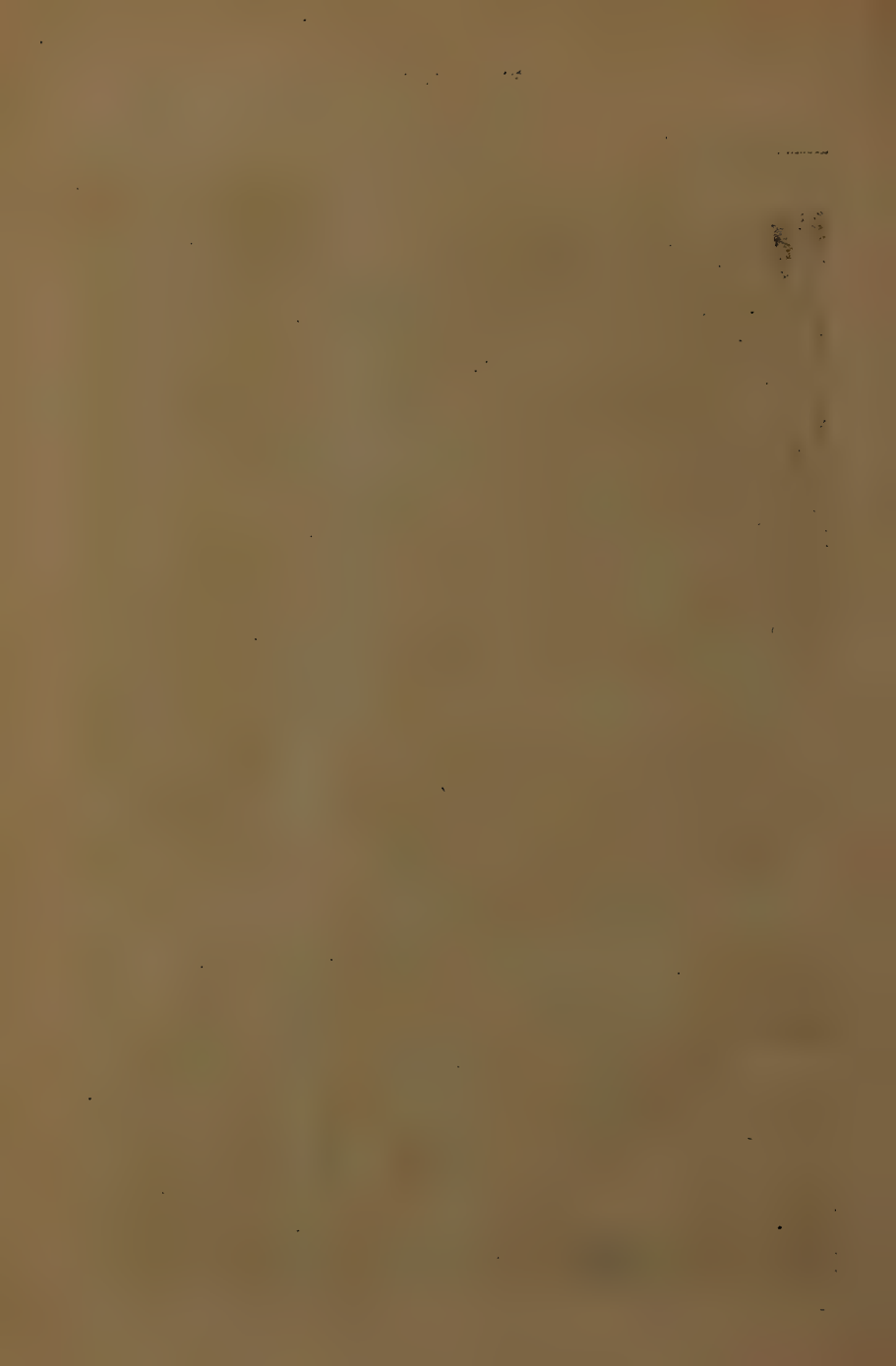


PLATE XXIV.  
Sugar-cane Fungi of Porto Rico.

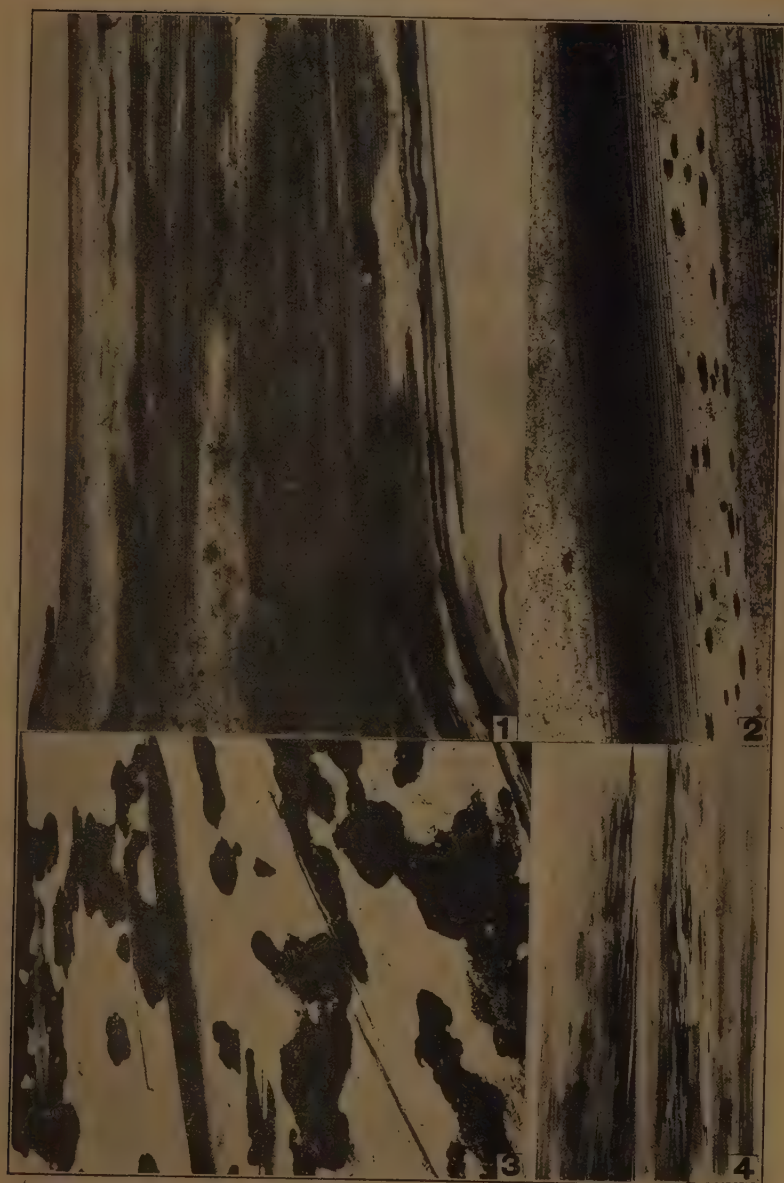




PLATE XXV.  
Sugar-cane Fungi of Porto Rico.

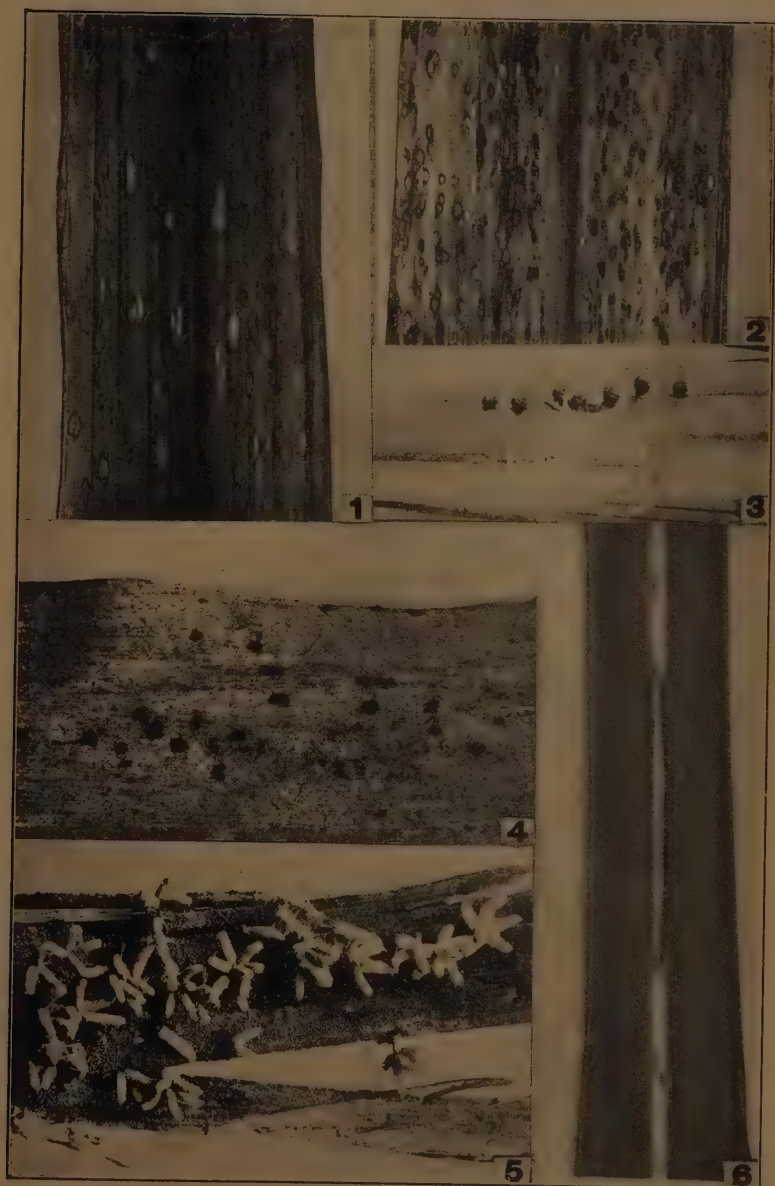






PLATE XXVI.

Sugar-cane Fungi of Porto Rico.





# PLATE XXVII.

Sugar-cane Fungi of Porto Rico.







# PLATE XXVIII.

## Sugar-cane Fungi of Porto Rico.

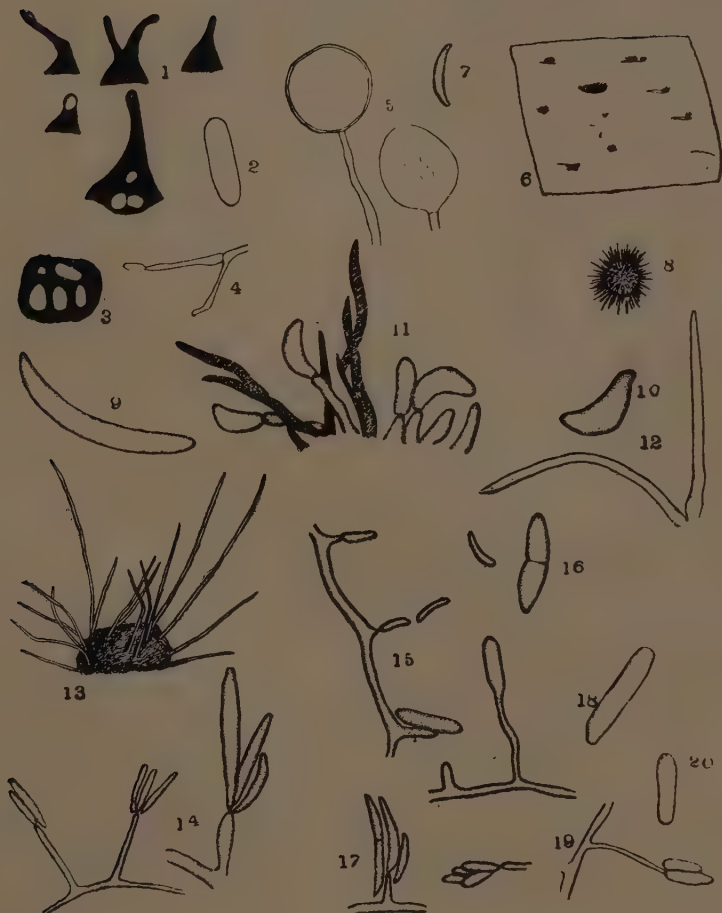




PLATE XXIX.

Sugar-cane Fungi of Porto Rico.





PLATE XXX.

Sugar-cane Fungi of Porto Rico.

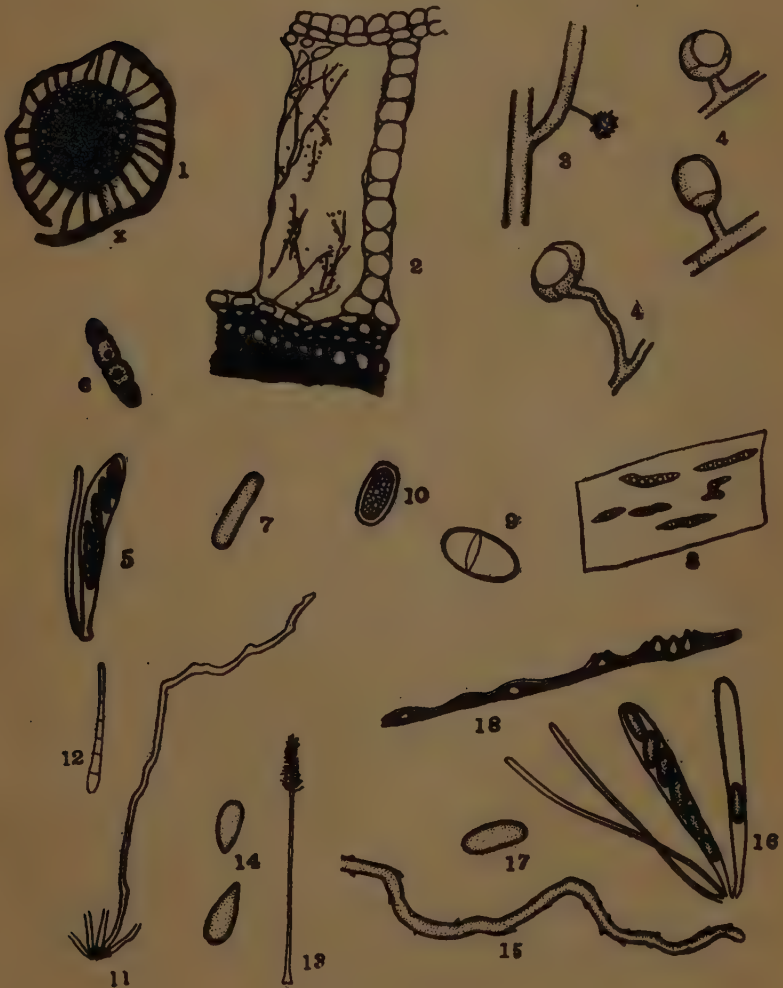






PLATE XXXI.

Sugar-cane Fungi of Porto Rico.





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